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Psychological Monographs

EDITED BY
JOHN F. DASHIELL
UNIVERSITY OF NORTH CAROLINA

COLOR-MUSIC

By

THEODORE F. KARWOSKI
AND
HENRY S. ODBERT
DARTMOUTH COLLEGE

Published for the American Psychological Association by
THE PSYCHOLOGICAL REVIEW COMPANY
THE OHIO STATE UNIVERSITY, COLUMBUS, OHIO

Publications of

The American Psychological Association

Willard L. Valentine, *Business Manager*

Psychological Review

Herbert S. Langfeld, *Editor*
Princeton University

Contains original contributions only, appears bi-monthly, January, March, May, July, September, and November, the six numbers comprising a volume of about 540 pages.

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The Ohio State University, Columbus, Ohio

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ACKNOWLEDGMENTS

The writers wish to thank the following organizations and persons for various services without which this monograph could not have been produced. The Carnegie Corporation granted funds to meet the cost of the colored plate. The Green Serenaders and Charles Voelker of the Department of Public Speaking of Dartmouth College coöperated in making the record of musical compositions used in this study; and Charles E. Osgood made a record of special sound effects. Harry V. Bamford selected the subjects in the early stages of this research; Frank G. Pickell did likewise in the later stages in connection with his study of the personality characteristics of synesthetes. Mrs. Elmer Smead volunteered her services in the typing and arranging of the various parts of the manuscript. John R. Scotford, Jr., served as subject in these experiments and made up the color plate printed in this monograph. To all of these the writers are much indebted.

FOREWORD

Colored hearing is a phenomenon with important implications both for the psychologist and for the artist interested in developing new art forms. The psychological problems involved are numerous and well known. The present writers were originally interested chiefly in the nature and frequency of color effects in a male college population when musical phrases rather than single notes were used as stimuli, and in the relation of the color effects obtained from complete musical phrases to the effects obtained from separate measures or chords of those same phrases. As the study progressed several different types of response became apparent, and widespread relationships with other fields of psychology became increasingly obvious. In its various forms colored music proves to be not at all strange or unusual.

The present findings thus pertain to the problem of color-music as a possible art form. The theater and the opera have long used colors as a background for music, and inventors of various color organs attempt more specifically to relate music to synesthetic experience. The development of colored motion pictures and television will increase the facilities for the visualization of music enormously and will promote ingenious attempts to advance color-music as an art. Traditional scientific investigations, on the other hand, have offered little hope for the systematic development of color-music. Writers have suggested that colored hearing is quite rare and that the experiences of colored hearers are so individual that no common system could fit them all. It is possible, however, that this negative attitude results partly from the concentration of many investigators on the relationship of colors to single notes. This analytic approach appears to miss many relationships on more complex levels. Subjects who have color experiences with music frequently have no such experience with single notes.

The frequency and fluidity of the phenomena here reported suggest real possibilities for the development of color-music. Even to many subjects who do not have any synesthetic experiences the idea of colored music is quite comprehensible. And most of those with clear color patterns of their own are not so rigid in their systems that any deviation would be intolerable to them. Art is a field that can tolerate many exceptions to its rules.

COLOR-MUSIC

I. Introduction [1]

A determination of the nature and frequency of colored responses to music requires some sort of standard material which can easily be presented both to groups and to individuals. The writers used a locally-produced record which included short phrases of popular music, and single measures and notes taken from those phrases.

Popular music was used because it promised to arouse the interest and coöperation of the student subjects. An attempt was made to secure as wide a variety of selections as possible, ranging from the fast rhythm of " White Heat " to the slow smooth melody of " Solitude," and including a modern arrangement of " Jingle Bells " which it was felt might arouse some of the more obvious external associations.

The measures of two of the phrases were recorded separately to reveal something of the relation of disjointed phrases to total patterns of music in the evocation of colored images. Thus seven measures of " Squareface " and a final chord which constituted a complete phrase were recorded as a unit, and then each of the measures was recorded separately. The introductory chords of the measures were also recorded. The same was done with " Jingle Bells." [2]

This record served as the basic material for three main lines of investigation. Students in class groups first indicated on a questionnaire any color responses obtained while they listened to several parts of the record. The more positive cases later listened to the same selections in individual conferences, drawing their photisms when possible.[3] Finally a certain number of subjects drew photisms again for the same selections after a period of eight months.

---

[1] General discussions of synesthesia and extended bibliographies are presented by Friedrich Mahling [in Anschütz (1)] and by Ortmann (10). A recent treatment of color hearing appears in Vernon's book on perception (17).

[2] A part of the record not used in the present experiment included a number of chords and finally the same single note played on a number of different instruments, which it was felt might be used for studying the influence of timbre on synesthesia.

These three lines of investigation are discussed in the next three sections. Section IV also includes material on the relation of total phrases to separate measures of those phrases. Later sections consider the nature of colored hearing and the promise of color-music as an art form.

II. FREQUENCY OF COLORED HEARING

In an attempt to determine the frequency of colored hearing, the experimental record has been played to a total of 274 students in introductory psychology courses, 148 in the spring of 1936, 126 in the fall of the same year. Results in the two groups showed such interesting differences that the procedures are described in some detail. The spring group will be referred to as Group A; the fall group as Group B.

Students in Group A had already encountered a casual reference to synesthesia in their reading and in class discussion. The present study was not taken up in connection with synesthesia but was introduced quite arbitrarily while the class was studying abnormal psychology. Each student was presented with a copy of the following questionnaire, on which he recorded his experiences after the playing of each of eight selections.

A QUESTIONNAIRE FOR SYNESTHESIA

Introduction:

It has been suspected for some time that the presence of chromesthesia, or "colored hearing," is more common than hitherto believed. "Colored hearing" is a phenomenon in which individuals see, or seem to see, or associate, different colors with musical sounds or compositions. For example, hearing *Star Dust* might produce a sensation or feeling of "red." Chromesthesia is a form of synesthesia. Synesthesia occurs when sensations from one sense modality (*e.g.*, taste or smell) are called forth when stimuli of another sense modality (*e.g.*, hearing or vision) are presented. "Colored hearing" occurs most frequently among persons gifted in music, imagery, sense perception, etc.[3a]

---

[3] In the work with individual subjects sections of three other records were also used. One of these was a record made locally which included reproductions of fragments from a number of classical and popular records. Another was Metfessel's "Record of Sound Effects" (distributed by C. H. Stoelting Co., Cat. No. 42059), a few parts of which were played to obtain added information about the range of response of certain subjects. The third was a complete recording of Tschaikowsky's "Dance of the Flutes," played for a few subjects who were disturbed by the fragmentary nature of the other selections.

In the following experiment, eight different tests will be given. During the playing of each one, close your eyes, relax, and note what sensations, feelings, emotions, etc., are called forth. Then, after each test, answer the three parts of question "A," placing yes or no in the appropriate blanks.

A. When the music was played, did you

	1.	2.	3.	4.	5.	6.	7.	8.
(a) *seem to see* a color, or colors?	......	......	......	......	......	......	......	......
(b) *associate* a color or colors with the music?	......	......	......	......	......	......	......	......
(c) *feel* a color response?	......	......	......	......	......	......	......	......

B. There are several sense experiences such as, hearing, vision, touch, taste, smell, pain, cold and warmth, etc. In listening to the music, was there a synesthetic response in any of these, associational or otherwise? (the normal auditory response being neglected) ....

(a) If so, describe:

C. Have you ever noticed any sort of synesthetic response previously? (for example, smelling a rose might awaken a sensation of stroking velvet.)

(a) If you have, comment upon it in the space below:

Students in Group B were tested before there had been any discussion of vision or synesthesia, in an effort to avoid any influence of suggestion. To elicit responses in terms of mental content, the experiment was introduced by a discussion of the introspective method. The first twenty minutes of the class hour were devoted to indicating the full and detailed nature of many introspective reports, the distinction between description of the stimulus and description of conscious states, etc. Especial care was taken to make no mention of color experiences in this discussion. The students were then asked to close their eyes during the playing of the music and to write their introspections after

[3a] While this last statement is based on suggestions in the literature, it may be open to dispute. It was inserted in the questionnaire, however, partly to reassure students who might feel that colored hearing is an abnormal experience.

each selection, indicating any sensory, imaginal, or emotional experiences. After their last introspections they were given the same questionnaire that had been used the previous year, and the same eight selections were played again. At the conclusion of the second playing of the series students were asked to notice whether they had given color responses the second time but not the first, and if so to indicate why they had not given them the first time.

As might have been predicted, the introspections were quite uneven and unsatisfactory from a scientific point of view. A small number of synesthetic responses appeared, but more frequently subjects stated later that they had had color experiences the first time, but didn't think of reporting them.

TABLE 1

PROPORTION OF SUBJECTS GIVING POSITIVE ANSWERS TO VARIOUS NUMBERS OF ITEMS

	Seem to See		Associate		Feel		No Positive Report	
	A	B	A	B	A	B	A	B
1 item	.08	.29	.09	.23	.10	.20		
2 items	.01	.17	.08	.28	.04	.10		
3 items	.02	.13	.01	.26	.03	.11		
4 items	.00	.10	.00	.09	.00	.02		
5 items	.00	.04	.00	.08	.00	.03		
One or more items	.11	.72	.18	.94	.18	.46	.69	.06

Turning to the questionnaire results, we find a fair proportion of possibly synesthetic responses in both groups, but perhaps the most striking aspect of the results is the great difference between the reports of the two groups. Table 1 presents the results for both groups for the first five selections.[4] Results appear as proportions rather than as raw figures merely to facilitate comparison between the two groups. The table is to be interpreted as follows: 8% of the subjects in Group A gave a positive answer to the question, "Did you seem to see a color, or colors?" for one (and only one) of the five selections; 1% gave a positive answer for two of the five selections; 2% for three; none reported seeming to see color for four or five selections. A total of 11% of the subjects in Group A reported seeming to see color with at least one of the five selections.

---

[4] Since the last three selections had to be omitted in one class of 20 in Group B, the answers of all subjects on these items are omitted in the interests of uniformity. We may note in passing, however, that this restriction makes some difference in the total results for Group A, though it does not for Group B. Ten of the 102 subjects in Group A who showed no positive response on the first five selections showed at least one positive response on the next three. This would reduce the proportion of completely negative cases in Group A to 62%.

One is immediately impressed with the difference between the proportion of negative papers in the two groups—in Group A 69% gave no positive answers on any question for the first five selections, while in Group B only 6% showed equally negative results. This contrast points clearly to some significant difference between the procedures or the composition of the two groups. (The difference between the two proportions, in fact, is fourteen times its standard deviation.)

We can only speculate on what the difference or differences may be. Since the seven classes in each group showed fairly uniform results we cannot look to the influence of one specific face-to-face group as against another. The fact that Group A had had about five more months of psychology might have had influences in either direction. One might have expected that they would be more sensitive to photisms. In the other direction they may have learned enough of suggestion in their contact with social psychology so that they discounted any suggestion involved or were positively afraid of being duped. They may have suspected some relationship of synesthesia with abnormal psychology, which they were studying at the time. Group B, on the other hand, may have been made more attentive by the discussion of introspection. Or, finally, the fact that the records were played twice in Group B may have made some difference. (One student, in explaining why he indicated color experiences in the questionnaire but not in the original introspections, said, "I saw color here because I was looking for it, also it was the second time I had heard the music. I wasn't bothered by other factors.")

The contrast between the results from the two groups suggests that figures on the incidence of synesthesia or any sort of imaginal experience which are derived from questionnaires must be received with considerable caution. This is true even when, as in the present study, the questionnaire concerns experience in a limited and apparently controlled situation. From Group B 94% might appear to be synesthetic, or at least 72% (the percentage of those who reported that they "seemed to see" color with at least one of the selections). From Group A the corresponding figures are 31% and 11%. It might be argued that suggestion has made some or all of these figures misleadingly large. On the other hand, there are reasons for believing that the conditions of the experiment were not ideally conducive to synesthetic experience. Some of the subjects individually studied reported that they had been disturbed in the group situation, and others reported that they more frequently had color experiences with music less familiar or more symphonic.

If we are pressed to derive one set of figures from our results we may do so by combining the two groups. We then find that 39% "seem to see a color or colors," 53% "associate" a color, 31% "feel a color response" with at least one of the five selections. Finally, 60% of the subjects give at least one positive answer for at least one of the first five selections. But it must be recognized that this figure results from adding cases from unlike groups, and also that a different procedure or even a different group of selections might appreciably raise or lower it.

An estimate of the frequency of colored response to musical selections is important because it indicates how large a community color music (as an art form) may serve. Our data show that at least 60% of the subjects tested give some kind of color response to music. Under some circumstances fully 90% have responded colorfully. The more specifically photistic group is much smaller but by no means insignificant since our incomplete survey from Group B produced twenty-four synesthetes or 19% of the group of one hundred twenty-six. We are reasonably sure that more cases would have been uncovered if all subjects indicating color responses to music had been individually investigated. Due to limitation of time only twenty-seven of the best prospects, as revealed by the questionnaire, were selected as possible color hearers. Of these, twenty-four proved to be such, three being rejected as having simply meaningful though colored associations with music.

By color associations we ordinarily mean that the individual obtains colored images with music. However, there are people who simply think of color on hearing notes without having any images at all. We know of no statistics for such color thinking but Kerr and Pear (6) have recently developed a technique by which they elicited synesthetic responses by asking people to give words describing voices which they heard on a graphophone. It was found that 53% of the people used words which indicated synesthetic capacity. This method might be used to pick out the individuals who respond in symbols of thought rather than photisms or images. If such cases are included it seems safe to say that a good majority of the population in one way or another relates colors to music.[5]

III. Types of Response

Of greater significance than a mere knowledge of the presence or absence of a visual response to music is a knowledge of the nature of such responses. While the questionnaires were not adequate to furnish such information, they served as a ready means of selecting promising subjects for individual study. Ten subjects from Group A and twenty-seven subjects from Group B were selected on the basis of frequency of positive response to the questionnaire.[6] Each of these subjects was studied individually by one or both of the authors, in an attempt to determine as fully as possible the nature of his visual responses to music and to other auditory stimuli, and also the nature of his visual imagery in general.

---

[5] The findings of some other investigators are of interest in this connection. In Stanley Hall's (4) observation of Boston school children twenty-one of the fifty-three interrogated were found to have synesthesia. Among twenty children observed in Amsterdam, Révész (14) found nine who were synesthetic. College girls at Wellesley were 15.9% synesthetic (2). At Vassar a similar figure was reported (16). Diserens (3) quotes figures for colored hearing ranging from 12% to 43%; Mudge (9) gives 9 to 15% of fifty subjects, of whom only eight failed to give any color responses to music. Ortmann (11) finds a proportion of 28% among his pupils; Vernon says that 16% of those who answered his questionnaire had more or less well established connections between color and music and he quotes Sabaneev as finding 21% (19). Wheeler (21) estimates the frequency of synesthesia among adults to range from 9 to 15%; among adolescents as high as 25%.

Each subject was told that he was called in because the authors wanted to learn more about the nature of the visual experience he had reported in the class study. Care was taken to put the subject at his ease, and it was made clear that he should feel under no pressure to "produce" visual experiences if such did not occur spontaneously. The subject sat in a darkened room with his eyes closed until he reported that he experienced no after-images. He then listened to one of the selections of the experimental record, with instructions merely to relax and listen. He was asked to report any visual experience, and if possible to draw it with colored pencils which were available in a wide range of colors. Notes were taken of any comment about the experience or about the drawings. The same procedure was followed for each selection on the experimental record and for a number of other sound effects. Later the subject was questioned about what the experiences meant to him, and about any tendencies toward entoptic effects, eidetic imagery, etc. Tuning forks were provided, as were pictures and a projection field for after-images. The room could be made relatively dark to test entoptic colors. Sometimes the room was darkened more or less continuously during the conference, the experimenters working by means of a pocket flashlight. In other words the conferences were of the nature of clinical meetings rather than question-and-answer sessions.

Full notes taken in the course of these conferences furnish many valuable hints as to the factors involved in colored music.

[6] The ten subjects selected from Group A were first studied by Harry V. Bamford, whose results appear in an unpublished thesis on file with the Department of Psychology of Dartmouth College. Eight of these subjects returned after eight months for further study by the authors. Their results are considered in the following section of the paper, on consistency of response.

The selection of subjects in Group B was made by Frank G. Pickell as part of a study of personality characteristics of synesthetes, the results of which also appear in an unpublished thesis on file at Dartmouth College (**12**).

As the data accumulated it became obvious that there were several broad patterns of response which recurred with some regularity. Some of these patterns conform more closely than others to traditional views of synesthesia, and before attempting any selection it seems wise to list the chief sorts of visual response obtained to musical selections. Subjects report:

1. Cloud, film, or veil effects, which may billow vaguely.
2. Spreading sheets of color, which overlay one another.
3. Points or limited areas of color, which may move or expand or contract with changes in the music.
4. Developing bands or ribbons of color as follows:
   a. Simple band. This is a band of varying width, which shows only one color at a time for its whole width, but which may change color more or less rapidly. Several of the "earlier" colors may be visible at one time. These bands almost always show a left-right development, and may or may not show movement up or down, sometimes with changes in pitch.
   b. The "sound track." The description "sound track" came to be applied to a band developing from left to right, within whose width single lines for the various instruments rise and fall with the pitch.
   c. Multiple band. This is a band in which two or more colors maintain a constant relationship one above the other throughout the selection, the whole band rising and falling with changes in pitch. (In one case this band tended to weave about, filling the whole field with color which resulted in a pattern somewhat like the following type.)
5. Colors which gradually fill the field in complex patterns.
6. Meaningful images, which may show some dominant color or degree of illumination.

All of the classes but the last involve photisms, which have generally been regarded as the best criterion for the presence of synesthesia. Meaningful images, on the other hand, have generally been regarded as quite extraneous to the phenomenon of synesthesia. Several facts, however, lead the writers to feel that *meaningful imagery and synesthesia are often very intimately related.*

In considering reasons for linking imagery and synesthesia we must turn from isolated responses to consider the range of response of individual subjects. An individual subject seldom shows all of the sorts of response listed above—in fact his range of response is generally narrow enough to justify classifying individuals into groups as we do in the remainder of the section. But frequently meaningful images seem intimately related to photisms.

Thus one subject reported seeing an orchestra as a result of hearing a certain musical selection, but strangely enough the orchestra was fringed with red light. Another subject consistently sees orchestras illuminated by colored lights conforming to the character of the piece. Another person of predominantly associational imagery reported that the transitional states between specific images contain color patterns. (This subject recalls color photisms with the notes of the musical scale in his childhood although he no longer has this experience.) Another obtains images for " neutral " music, but any striking change in intensity or quality evokes a corresponding photism. These cases might be regarded as illustrating what happens when strong visual imagery and synesthetic tendencies alternate or are superimposed.

In still other cases we seem to find a borderland where a similar visual experience might be interpreted by one subject as a color pattern and by another as a meaningful image. Certainly observers viewing the drawings of certain subjects would have difficulty in knowing that one drawing represented a photism described by a subject as " blue in the upper part of the field, brown in the lower "; while a similar drawing was described by another subject as a beach scene. The introspections of one subject give a hint of a process which may frequently be taking place. He said: " I saw red orange light (must be the sunset); below it a large mass of blue (must be a lake)." The assigning of traditional meanings to experiences not otherwise comprehensible is a tendency familiar in other fields. It is possible that some general attitude of the individual determines whether he will accept a photism as a pattern of colors or whether he will mold it into or interpret it as a meaningful image. In this connection it is interesting that Pickell (12) found that *our subjects reporting the most fully developed abstract photisms were significantly more introverted than the group from which they were selected,* while those reporting a predominance of meaningful images were if anything a bit on the extroverted side.

Cases were also found in which images were more fully developed, but still seemed " overloaded " with color. One subject consistently made reports of the form: " Black—and a negro orchestra." He was asked at the end of the experiment whether he obtained the color first or whether he had reported it first because he thought it was expected of him. He replied that the color was the striking part of the experience although at times he could not be sure which appeared first.

Even quite specific memory images are sometimes found to recur largely because of their color values. One subject who usually experiences elaborate abstract photisms reports that three meaningful images also frequently recur. These seem to be derived from three colored pictures which hung in the subject's room during his childhood. Each is now experienced in connection with a certain sort of music. A scene of water, land, and sky in green and blues occurs with selections having little melody; a hill with a tan-colored field occurs with music suggesting power; a desert in yellows, red, and blue-gray occurs with light music. Although this subject ordinarily experiences chromesthetic patterns, when these association pictures are called up they fit in with the color of the music and modify the form. This mutual interaction is not a rare phenomenon.

All of the above cases suggest that subjects with meaningful imagery should not be lightly regarded as falling outside the sphere of colored hearing. We have found evidence of genuinely spontaneous photisms in imagery which superficially seems merely meaningful. It appears likely that synesthesia, vivid visual imagery, and possibly eidetic imagery are closely related.

A classification of color-hearers. The problem of visual imagery as related to synesthesia has a particular bearing on our results because it has presented complications with respect to a classification of color-hearers. We have already pointed out that the range of responses of an individual is usually considerably less than the total range of the group, and we have hinted that the individuals might be classified into sub-groups. Such a classification has the practical advantage of indicating the sorts of audiences which color-music as an art form may anticipate. The chief alternative to such a classification would be a dimensional arrangement. For instance, subjects might be arranged along a single dimension according to the degree of complexity of their photisms, with the degree of imagery treated as a separate dimension. The imagery would remain a disturbing factor, however, in determining the complexity of a subject's photisms. There are also indications that different psychological mechanisms may be involved at different levels of complexity. We have, therefore, favored a classification of all subjects into three groups. Those with imagery are classified separately, although within the group there is a considerable range in strength and complexity of photisms. This range of photisms is further emphasized by placing the imagery group between a group whose colored hearing is rudimentary, and a group whose colored hearing is quite complex.

The division of subjects into three groups has evolved during our consideration of the results. The groups or "types" are obviously not separated by sharp boundaries and each group includes a considerable range of responses. It should be pointed out, however, that our results indicate that each of these groups may be correlated to some extent with special fundamental mechanisms. Thus the phenomena of the rudimentary group resemble entoptic colors and we feel that in some subjects their synesthesia is simply a vague patterning of entoptic colors to conform to music. In the synesthetic imagery group the fundamental mechanism is the ordinary meaningful visual image as modified by music. In the complex group the subjects show a capacity for translating more aspects of the auditory stimulus into visual sensory content than any subjects from the other groups. This capacity is comparable to that of the eidetic whose visual image contains minute elements of the visual stimulus. It is not merely a question of vividness but rather a correlation, point for point, between the stimulus pattern and the synesthetic pattern. In this sense the complex synesthetes are analogous to eidetics in the field of visual imagery.

In the following classification one or two case studies illustrative of the rudimentary and synesthetic imagery groups are presented. The responses of other subjects of these two groups are condensed in tables, since a complete presentation in the case history method would be unwieldy. All cases of complex synesthesia, however, are described in detail because of the special importance of the complex type. The frequencies of these groups as found in canvassing the 126 subjects of Group B are as follows: rudimentary, 11; synesthetic imagery, 9; complex, 4. The two rudimentary and eight complex cases in Group A are discussed in the section on consistency of response. In regard to the discrepancy in the frequencies from these two groups it should be pointed out that neither group was fully canvassed, but that Group B was more fully examined than Group A.

1. *Rudimentary color-hearing.* The individuals in this group differ in degree of form and color. Some experience more form than color; others color with little form. The form pattern is fragmentary compared to the highly pronounced cases of synesthesia but the different types of form pattern are indicated in these subjects just as they are in the more striking cases. MacGregor has hardly any configuration—at most a change in brightness or value of the photisms which resemble entoptic phenomena. Chapin has moving rounded forms which fill more and more of the visual field as the music becomes more complex. Daley has colored spots and patches moving back and forth in third dimension. Movement is the striking aspect. Jackson obtains vague background colors, like entoptic colors, but they are placed in different parts of his visual field. There is also an

indication of form in the tendency for rounded edges in the photisms. In the case of Frank these form-colors often yield to associations.

Case study: [7] *Daley*

1. Hardly anything visual—just sense of ease and rhythm.

2. Like sense of yellow. Something brilliant flashing. Not quite same as memory image—like feeling of it more than actual image. Appeared only on last note. No definite shape. Couldn't call it up again.

3. Just purple—seemed to build up. (No change with music after it was built up. No form.) "Like looking at a purple wall." "Instead of seeing all black I saw all purple."

4. Had specific meaningful association. Sleigh.

5. "Couldn't explain it but I had two spots of blue—seemed a little bigger than a silver dollar." When questioned about background reported fringe of golden dots or sparks with rest of field black. Blue things seemed to come nearer and to go back.

6. Nothing.

7. Spots of white against black. No pattern—like black shot across with white. Pretty much from all directions. (Drawing shows that there was tendency for spots to concentrate on the center.)

8. Perfect black oval—a little white around the edges.

1. (Repeated.) Gave white dots—more stationary than in 7.

9. Introspection vague. "At times a blank, except possibly at times it shaded up." (Waved hand diagonally.) "The last was a bit brighter."

10. At first pin points of light—yellow or white—at last red. "Almost like holes in a dark dead background with light flashing through."

Tuning forks and Metfessel sound effects caused no visual experience. The subject reported "pretty clear" visual imagery. After looking at a sheet of red paper he obtained a red memory image, after which he saw a touch of red on the top of a sheet of white paper. He obtained no image after looking at a complex picture. He asked, "What about seeing things where they are on the page?" Used to try to remember bill-boards when out driving as a child. Feels he obtained no real eidetic effects. At first reported no entoptic phenomena but in later discussion volunteered that he sees colors before going to sleep. Does not get color often with music. "Don't think I ever thought about it." But reported having such experiences before the experiment—principally the same as obtained before going to sleep. Is not enthusiastic about music although he goes to concerts and sometimes gets color when eyes are closed. Reports that color adds to enjoyment of music which he likes but doesn't add much to music he dislikes. Has noticed no system but suggested that pitch might go with brightness. Does not play instruments—family is only moderately musical. No special interest in dramatics, art or poetry.

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[7] In the case studies which follow, the numbers refer to the following selections: (1) Squareface, (2) White Heat, (3) Moanin' Low, (4) Jingle Bells, (5) Solitude, (6) Chaser (a short syncopated succession of notes such as is often used for transitions in popular music), (7) Squareface (first measure), (8) Squareface (second measure), (9) Overture to the "Merry Wives of Windsor," (10) Saturday Night Function (Duke Ellington).

The added information concerning interest in music, art, etc., was obtained after the playing of the records.

Case study: Jackson

1. "The music sort of lightened the whole dark aspect, and light blue appeared at the top but dark blue at bottom." (Broad double-layer type of photisms.)
2. "Jesus, it is green this time. It seems stupid. Isn't it funny you should get these things? Do all people see colors in music? The green was at the bottom and light gray at top."
3. "This strikes me as blue but not as prevalent as in first number. Seemed off to right and a little streaked."
4. "Saw white but I think I connected this with 'Jingle Bells'; also a splash of green on the top."
5. "Sort of an hour-glass figure with a blue color at top and fading away to black at the bottom."
6. "Not much."

At this point subject heard the "Dance of the Flutes" in its entirety but did not report color. Tuning fork 320 ~ gave a streak of flat yellow (tannish) across the black. No. 384 ~ gave the same color but in a more solid mass at the top of the field. No. 256 ~ gave no color.

When he hears music he sees a large boundless field. Colors appear in various parts of the field—sometimes at the top, sometimes at the bottom. He has formulated no system to describe this fact. When tested for entoptic phenomena reported simply a gray dark field. Visual and auditory imagery good. He has not had musical training but has a good ear for music. Picked up bugle and harmonica while a Boy Scout; played ukulele and sang with a quartet in the glee club at prep school. Does not attend musical recitals and is not particularly interested in art. Does not get much out of classical music—prefers familiar melodies.

Table 2 shows the colors obtained for the first five selections. The degree to which the various selections evoke characteristic colors will be discussed in connection with Table 3. One interesting fact shown in the present table is the tendency of certain

TABLE 2

Colors Reported for the First Five Selections by the Rudimentary Group

	No. 1	No. 2	No. 3	No. 4	No. 5
Anderson	Purple	Assoc. Wh.*	....	Blue	Blue-Wh. Flashes
Bodge	....	White	Orange	Assoc. Wh.	Deep Black
Chapin	Purple	Lt. Purple	Purple	....	....
Daley	....	Br. Yellow	Purple	Assoc. Im.*	Blue
Frank	Green	Red-Orange	Assoc.	Wht. Red Blk.	Black
Jackson	Blue	Green	Blue	Assoc. Wh.	Blue
Jones	Green	Green	....	Purple	Orange
Jones, P.	Dark Blue	Lt. Gray	Yellow	Bright Yel.	Red
Kwis	....	Or. Blue	Assoc. Im.	Assoc.	Red
MacGregor	Blue	Dark Blue	Light Blue	Darker	Black
Sinclair	....	Light Blue	Assoc. Im.	Assoc. Im.	Dark Blue

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* Assoc.=Association; Im.=Image.

subjects to react to all the selections within a very narrow range of color. It might be stated that some of the subjects felt that the selections were very similar. One is tempted to see some suggestion that these photisms are elaborations of entoptic colors since such colors are frequently blues and purples. The suggestion is made more feasible since different individuals have different color fixations such as purple, blue, or green. In this connection it should be pointed out that these subjects readily obtain entoptic colors, only three of them failing to report colors when eyes were closed in the darkened room.

No complete explanation can be based on entoptic colors because music brings change in the values of the color. There are several ways in which this change might be brought about. One way is on a predominantly sensory level. Zietz, for instance, found that ripples in an auditory stimulus are accompanied by ripples in visual after-images (22). Changing physiological rhythms such as blood circulation may lower entoptic thresholds. (One of the experimenters has noticed that when he has a cold his entoptic colors are unusually pronounced.) Finally, emotional variations may affect the entoptic colors. One subject volunteered to say that synesthesia is not a reflex since it depends on the mood of the individual. Tuning forks may be less productive of photisms partly because they are less emotional. Even with musical selections some of the subjects require time for the effects to build up, which is in keeping with the delay in the reaction of the autonomic system as compared with the peripheral system.

2. *Synesthetic imagery type.* In this group the essential differentiation is the dominant rôle played by visual images from personal experience in modeling the synesthetic patterns to present meaningful pictures. If these pictures were always meaningful reproductions of experience there would be no necessity for considering the cases as synesthetic at all, but we have already presented evidence that without tendencies for color hearing the picture would be different. It seems that the picture is often adapted to the colors. Thus while Tower always gets a picture of an orchestra, he has noted that with moderately fast music the orchestra seems illuminated by ordinary electric lights; with slow

music, by dull blues and grays. His synesthesia seems to be largely in terms of general illumination. When meaningful associations are not readily obtained then the subject reverts to the simpler pattern type of color arrangement. This is probably one reason why many of these subjects claim that they get more colors with classical music even though they prefer popular music. Popular music has too many associations.

Chellis gets images of people or couples dancing with jazz music but color patterns sometimes form even with popular selections. (Incidentally Chellis reports that fast music determines reddish hues while slow time produces blues and blacks.) Dakin drew typical synesthetic patterns when he didn't get conventional pictures. He distinguished association colors from photisms in his reports. When he drew what seemed to be a conventional picture he was particular about the exact shape of the mountain, and in another scene he placed a brown palm tree on top of a green hill. The tree seemed to be the striking figure. Warrener gave many pictures. In one instance he represented a green palm tree elongating out and moving upward with the music. Wehmeyer gets flashing flames of light with lively music and grayish and bluish mists or clouds moving and expanding with the music. His images were sometimes so primitive as to make him seem a border-line case between the rudimentary and synesthetic imagery groups. (Dakin might also be considered a border-line case.) One consistent feature of all these color effects is that they are in continuous movement and the movement is almost always from left to right. Only Valier reports that when he obtains directed movement it is from right to left. He shows an interesting combination of imagery and pure color effects. During the introduction to a piece he follows a line (usually of light brown against dark) suggested by the note sequence. Then meaningful images appear. If, however, a striking or shrill passage occurs the line flashes back again. Mearns also obtains images for some pieces, lines for others (and for tuning forks). Kelleher suggests that colors from real associations sometimes tend to obliterate colors naturally produced by the music.

Certain photisms are undoubtedly suggested by external associations of the music, as when subjects report red and green for "Jingle Bells" because it reminds them of Christmas. There is no precise way of proving that many of the other photisms are not due to associations. Slow music may be associated with blue because blue lights are frequently used with waltz melodies. Brighter lights probably are used with faster music. If this is so the question arises why the conventions should make this particular association. In any case not all people of rich visual imagery show photismic tendencies in their imagery pictures such as those noted above. In this study three subjects were discarded who had vivid visual imagery but who showed no tendencies for color photisms. With some people there is an unusual aptitude to associate colors with music and even if this much were granted we would still have to have a name for them such as color-hearers. Most of the subjects are somewhat consistent in the color effects they obtain with particular selections but others vary widely, even shifting from one color to another.

Case study: Kelleher

1. "At first no sensation. Then suddenly Pat Barrett's drug store with the green and white awning out and someone walking beneath it, then a red truck parked in the street."
2. "Flash of soldiers jigging up and down—olive drab—dry hay-colored field—spell of nothing—then an orchestra leader waving his baton."
3. "Ballroom—people dancing—I could recognize blue, light brown, and patterned dresses on the girls."
4. "Picture of men in somber-colored (brown, gray, black, denim-blue) clothes shoveling snow, white and dirty, in a street beside a red brick church."
5. "Two gray ships with limp, parchment sails. Smoke coming from the bow gun of the righthand ship. They drift apart. I see a sunny sea, and blue hazy hills on the shore behind them."
6. "A large railroad engine (seen only in part) rushing along with steam billowing from the pistons. I could see the wheels turning, but neither the track nor the ground."

In entoptic test got blues and greens. Sees patterns of color when excited just before going to sleep which he thinks may be due to "nervousness." Good visual and auditory imagery. Indications that he was eidetic when a child. Could picture anything he wanted. Used to think every note in scale had a color. (Can only remember that Do was blue, Mi was green, Ti was light blue.) Never got these colors in music, only when scale was played or whistled. Does not have experience any more. Also used to have colors for each number—one was black, two was blue, three yellow, four yellow, five brown, six black, seven green, eight red, nine dark, ten yellowish brown. Does not know why. Remembers asking his sisters about colors of numbers and they also had them, but their colors were different from his. Likes the sounds in language and wants to be a teacher of language.

Experimental conference shows that subject gets strong imagery with music. Images are usually personally toned, referring to personal experiences and intimate associations, such as he has with his father and the national guard and Scottish traditions. The bagpipe yields masses of color, and he thinks that these colors are due both to the music and to the associations he has for them. Subject utilizes his imagery in his work. ("Anyone who writes a short story or play must see everything in detail before one. I always do.")

Although subject's pictures are predominantly associational, he shows true synesthetic tendencies. As he says himself, "Tschaikowsky's marches put a riot of color in me." Always sees pictures of objects, *except in transition from one picture to another, when there are forms of color.* Likes medium tones, and low ones. Does not like sharp, high-pitched tones, the only high strings that he likes being those in "The Last Rose of Summer." When he hears it, he gets *light colors.* Low strings give *dark colors.* When asked if different instruments gave different colors, said that a flute is silver colored, with streaks in it; the lower tones of the violin are golden. He was asked to note the flutes as the "Dance of Flutes" was played. "At first, due to the fact that I was concentrating on trying to separate the flute notes, I got little more than moving light and dark (drawing in blacks). When I could get a clear run of flute music it looked like a thin flexible silver pipe being bent like a graph, up with the music and down as the music deepens. Then I suddenly felt as though I were about sixty feet down in a clear green sea, looking up at the troubled surface and the hull of a boat plunging up and down with the motion of the waves—all very distinct."

On tuning forks he got some color, particularly with the low forks, but the color varied somewhat with repetition. Concerning the rôle of synesthesia in his enjoyment of music he stated: "Colors are incidental. Never think of them when listening to music, but when relaxed and letting music pour into the ears."

Table 3 shows the colors obtained with the first five selections by the individuals in this group. A comparison of the colors in this table with those of the preceding table shows that there is consistency in the colors for selection 1. In selection 2 both

TABLE 3

COLORS REPORTED FOR THE FIRST FIVE SELECTIONS BY THE SYNESTHETIC IMAGERY GROUP

	No. 1	No. 2	No. 3	No. 4	No. 5
Chellis	Blk. & Wht.	Red	Gray Green	Blk. & Wht.	White
Dakin	Blue	Purple	....	....	Blk.-Blue
Haartz	Blk.-Green	Yellow	Dark Blue	....	....
Kelleher *					
Mearns	Grn. & Yel.	Blk., Wht., Gold	Blk. & Wht.	Red, Wht., Blk.	Blue-Blk.
Tower	Dull Red	Yellowish	Whitish	Assoc.	Brn.-Blk.
Valier	White	Brn. (Gold) Wht.	....	Grn. & Wht.	Dark Blue
Warrener	Blue	Orange	Green	Silver	Orange
Wehmeyer	Gray	....	....	Lt. Blue	Brightness

* Too many colors because subject experienced flight of pictures more or less in natural colors.

tables indicate a tendency for the colors to become brighter and the brighter colors are brought in more frequently. Selection 3 shows a variety of colors in both tables. For selection 4 both sets of subjects protest that there is too much associational content aroused by the piece. Selection 5 reverts back to the darker hues. These results check pretty well with the nature of these selections if we assume that faster and higher notes produce light hues and slower and lower notes the dark hues. The protocols also tend to substantiate the idea that sharp notes produce more definite configurations; continuously and gradually varying notes enhance blending of colors with relatively undefined borders.

Since the colors reported in Table 3 are abstracted from image pictures, the following descriptions are given for each subject to show how the colors were really experienced. In the previous group this was not necessary since their experience tended to be of the nature of photisms rather than actual pictures of objects.

Chellis. 1. Boy and girl dancing on ballroom floor containing black and white checkered floor with black and white columns.

2. Hazy images of people in bright native costumes dancing—predominantly red colors.

3. Slow winding river—grayish, with greenish gray bank, black tree on one side.

4. Black and white. No motion. Snow falling on street containing horse and sled.

5. Boy standing near girl. No color. There is a *white bright shining moon above their heads.*

Dakin. 1. " Sort of a running column of blue like rushing water, long waves moving across my field of vision on a diagonal. The waves seem to keep time with the music."

2. Purple color—movement—but nothing to distinguish it as such.

3. Nothing.

4. Too many associations from the past aroused.

5. Black to blue field, in motion as objects, fading into black after a short time.

Haartz. 1. Black seemed to lighten a little as in drawing.

2. Image of familiar dance hall—color of electric lights.

3. Image of dance hall in deep dark blue.

4. Contrast of white and green—tree to the right.

5. " At first blue, then red went over it which became like a sunset, then gradually losing red and turning black. The background was blue."

Mearns. 1. Green palm trees on yellow branch. " Rhythm must have suggested beach."

2. " A nigger orchestra with one golden trumpet." White jackets, black faces, one person standing up in back with trumpet.

3. " Two flashes—one at beginning, one at end." (Nothing in between.) A dance team " whipping right around." Girl in black full dress, man wearing

white mess jacket. Only other thing was boards of dance floor, going diagonally across.

4. " Red, white, and black—I got the picture of the sleigh, all right. Started off just with snow, then sleigh came along—black sleigh and horse—and people with red jackets."

5. " Definite memory picture—from a canoe. Mountain practically black, sky dark blue."

Tower. 1. " Slow music—red dull light. It's the kind of music one can't possibly think of as bright white or black."

2. " Electric lights, can't see them, fairly even illumination. Can't possibly draw it—too complicated. Can draw the band. Always see the band."

3. About same as before—the faster the music the brighter—slower the darker.

4. " Plenty swingy. Not sure of color. Just picture of dance hall floor, usually no dancer. I am near the platform."

5. " Very dark—seems to go brown and then brown to blue. A fairly even light over everything. Hard to see through it, it's so dark."

Valier. 1. " Old Victrola at home—but in a large white hall, like a palace in India or something."

2. " That always reminds me of a jazzy orchestra. Always see one man standing up in back row—playing instrument (trumpet). Only color brown metal flash, but not all the time. And white—don't know why white was there. Suppose men were wearing it."

3. " Not much image. Sort of followed music rising up and down again."

4. " That's green and white, and a dance band again." (Thinks probably association with local orchestra.)

5. " Definitely dark blue—sort of like night with somebody dancing." Saw colors first, then dancers in a familiar outdoor night club.

Warrener. 1. Drew ocean in two shades of blue and sand beach in light orange.

2. Orange oval shape—solid—rolling rapidly.

3. Green palm tree growing higher rapidly.

4. Silver sleigh bells.

5. " Falling balloons of different colors slowly falling." Repetition produced an orange bar moving against a gray background. Motion from upper right to lower left.

Wehmeyer. 1. Swelling, rising and falling mists. Deep dark gray.

2. Nothing.

3. Just jumbling—no color.

4. Picture of sleigh bells. (Drew it in blue.)

5. " Brightness sinking into darkness as in sunset." (Drew reddish orange sky with bluish hills below.)

3. *Complex synesthetes.* This group includes more "advanced" synesthetes, of the sort that have usually been the subjects of special studies. In this group, as in the others, we must point out that there are differences in degree of complexity or clearness of photisms and that the line of separation from other groups is

far from sharp. Nevertheless these complex synesthetes show some quite distinguishing characteristics. They represent more of the elements of the music composition in their patterns. Whereas the photisms of the previous groups often depicted the general tempo, mood, or pitch levels of the music only in a very general way, in the complex group these distinctions are more sharply defined. Another feature much more conspicuous is the assignment of separate rôles to the different instruments in a selection. In general their photisms are less schematic and more detailed, and in some cases there seems to be logical consistency in the relations between the various patterns.

In the literature cases similar to these have been referred to as pure cases of colored hearing. While this term may be useful in indicating a certain degree of clearness or amount of representation, it has little meaning otherwise because the changes from one group to another are gradual and continuous. It is this type which has been particularly studied as individuals and since they are relatively rare the impression has been created that colored hearing is limited to a few individuals.

In Group B only four subjects seem to fit this classification. (And of these, one feels very doubtful of his own experience, as we shall see.) Each of these subjects will be discussed individually. Of the ten subjects from Group A, however, at least eight would appear to belong in this group, with the other two falling in the rudimentary synesthetic group.

Case study: McKeever

McKeever in some respects represents a transition from the preceding group. For example, the red and green colors for "Jingle Bells" suggest association, but they were not in any meaningful pattern. The third selection produced the image of the face of a girl he had taken to a dance at Christmas, and the face was framed in red and green, which he thought were suggested by the decorations at the dance, though they were not apparently reproductions of the decorations. But as his effects were in general both vivid and without clear meaning he seems to belong in the present group.

Two brief preliminary selections from the Hevner music test both gave a "sort of red."

1. "Sort of blue." ("Any variation?") "Green for a while." ("Do you seem to see the colors?") "Not sure, but it appears that I do. Seems to come from bottom of visual field and spread out over three-fourths of the area." ("Any shape?") "Half round, like semicircle. Came up like crescent. Not uniform, some green. Rich blue to deep blue—not light at any time. Like

water-color wash—cloud almost. Outer border more or less indefinite—more or less green. Not as permanent as the blue."

2. Orange and light tan sheets coming in from sides of field of vision, converging at center—not very definite. ("Can you recall effects—reproduce first pattern?") "Yes, not quite as vividly."

3. (See above.)

4. Drew a symmetrical pattern in red and green. A center spiral was seen revolving. "Green is probably because piece is 'Jingle Bells,' a Christmas piece—thus I get an image also of Christmas colors."

5. Drew figure. "Got effect of blue coming in from edges, like diagram, crossing red field, and meeting in center, going away and starting over again."

6. Flash of red tending to yellow.

7. "Starts with yellows, then as deep tones come in, deep blue comes in as yellow fades away. From then on to conclusion various reds, light violets, oranges, yellow, some green, blues, tans, follow one another in rapid succession, seming to come in on top of preceding color."

8. "White yellow streaks dying away at same time note did."

9. Nothing.

10. Drew figure of yellow looping line enclosed by a purple line.

Chord of three tuning forks of reddish purple. Fork 256 ~, deeper purple—512 ~, light red—almost yellow, "that's what I've noticed fooling around with this—higher colors lighter." Could call up an image of American flag and of a picture seen briefly on wall—could not tell number of people in the picture. Can recall tunes, but not as well as pictures. Can hear sounds in head. Dreams have colors in them—never struck by it. Can imagine rainbow. Much music bores him, especially the heavier classics. Usually doesn't pay attention to color effects. Has noticed them at concerts, but they were not particularly vivid. When he closes his eyes while listening to radio he gets many colors. Louder music is more vivid, lighter.

Case study: North

North obtains colors usually in a moving band, although sometimes in flashes and patterns.

1. First blue and then light green and a yellow between. Beat in background suggested green color. Imagined it as trees. Music became light and that brought in yellow. Sort of wavy outline passing before the eyes.

2. Wavy red line.

3. "Mixture of about everything—oranges particularly. Deeper at beginning and getting lighter."

4. "Red and white—sort of intermingled lines of color. Probably more due to association. Ordinarily music like this—fast and definitely sharp—would be red and orange, mostly red. Softer music gives varying shades of blue and green—more of the cold colors." (Questioning about term, "cold colors," revealed that his father is a commercial artist.)

5. "Blue, richer, and purples. Colors would be blending in with each other. At very end a sort of discord suggests a dark brown splash. Purple—something in tone I can't explain—deeper than blue which suggests purple. Pattern—one big round thing—fills visual field. Edges indistinct—colors come—move inward. Got much movement in this case. Brown seen in one corner of it."

6. "Just one flash of reddish orange—background lighter—lines shot out. One spot spread out like a rocket when it bursts—started at center and burst out. Some things have depth."

7. "Purple I think. Color definite, not shape."

8. " Blue green turned to plain green at end—smear more or less. Going across. Bluer than drawn at first—started left, went across. At end could see all."

9. (Wondered about scratch or whistle which repetition showed to be a sustained violin note.) " Purple-black, with red line going through." When record was repeated with lights on and with his eyes open he saw an oval purple spot about five inches across, against a white card eight feet away.

10. " Not much background—line started up—as if coming toward eye, then danced around—bounced. Orange-red outside more. Left-right direction."

6. (Repeated.) Not clear—small.

6. (Repeated.) Light on. Reddish spot—about same as former projection. Less vivid than in dark, but large. Somewhat out of focus.

Noise. " No direct color—associations. First as if steam blowing out." Ordinarily doesn't get associations unless he tries to think of it. Blue association comes quicker.

Entoptic phenomena—gray band fringed with red at bottom—green cones. Imagery good. Saw yellow patch on paper after thinking of yellow. Imagined blue—got a blue patch on paper momentarily. Fork 256 ~, blue; 384 ~, reddish. Chord—greenish blue.

Tries to play piano sometimes but has little talent and does not play much. Mother plays piano pretty well, brother somewhat. Does not care for classical music, nor too much for jazz. Likes classical for studying, soft jazz for enjoyment.

Hadn't noticed colors until they were brought to his attention. No colors unless attended to. Color experience doesn't interfere with enjoyment—some blue color adds to enjoyment. Sees color in no definite pattern—it flows along in a stream. Has noticed that faster music is more red, orange, yellow—slower smooth music is blue and blue green. Heavier music such as some classical music is in very dark colors, purple, black, brown. A sudden crash usually gives a spread out effect but sometimes a contraction if there has already been a building up. Increase in volume brings things nearer the eyes.

Case study: Osgood

Osgood drew a pattern in lines and dashes for each of the selections and reported colors for each tuning fork. He reported that at times these effects were so clear that he felt he could reconstruct the music from them. A special problem appears here, however, in that he has consciously employed such line notations to represent music, which he cannot write in traditional notation. Osgood's uncertainty as to how much of his experience is immediate caused him to write out the following introspection about a month after the original conference:

" The more I think about my own synesthesia the more I think it is practically non-present. I said I thought I had it, but now I'm not so sure. In me, it seems to be induced as a means to record and remember arrangements, and as a method of seeing them.

" On certain short bits I have noticed color. There is one bit I remember where a trumpet nose-dives rapidly down a scale, and I see a jagged, lightning-like bright green line. On a few definite instances like this I do see color, but for the most part I'm afraid not.

" However, I do definitely *think* colors and lines while hearing an arrangement. When the trumpet section is taking the lead, I think of it, simultaneously, as thick green lines, equal in length to the length of the notes and equal in thickness to the weight and volume of the sound. If behind these trumpets should be a sax background, I'll see rolling blue lines, usually unbroken, behind and below the green. A drum break I picture as a spaced series of brown dots which seem to have depths varying with the volume, and if a cymbal follows, it will be pictured as a quickly vibrating, bright yellow line. On all this, I am *thinking* these colors rather than actually seeing them.

"I write arrangements of pieces in brief by this method. I use the colors I have mentioned above for this purpose (green for trumpets or trombone, blue for saxes, bright red for clarinet, orange for piano, thin yellow for violin, deep purple for bass viol, and brown for drums). As to how I happened to choose these particular colors, I cannot say. I know I couldn't picture them any other way; green would never fit the clarinet, for instance. Before I ever started to write arrangements by this method, I used to speak in terms of color. I might say something like 'that piece has a clarinet ride that sounds just like a bright red line shooting up into the sky.' In other words, having certain colors for certain instruments was not induced consciously as a means. Certain colors just seem to fit certain instruments in my mind.

"I have a very definite sense of depth. Certain colors seem to run behind others, the lead color always being in front, whether it's the loudest or not. There is also a sense of continuity. The pattern in my mind is most distinct and clear right in front of me, which is also right where the piece is being played, that is to say, the part of the piece that is being played is most clear and also in the center of a kind of mental backdrop. This backdrop is as though it were on a revolving drum, of which I am the center. (He drew diagram to illustrate this point.) There is a fading out of the part that has been played. In recall, I can bring back an entire arrangement, the basic structure of it at least, and then it appears to be in a straight line, steady and unmoving, along which, backward or forward, definite recall can move.

"This might be called 'mental synesthesia' for I do think these patterns in color simultaneously with the playing of a piece. But with my eyes closed, there is no visual coloring unless I actually throw the mental thought out into a color picture. If I do not think about the arrangement, however, there are only sounds and a thought pattern. This is muddled, but it is the best I can do."

To the experimenters it appeared that Osgood had had some degree of "true" synesthesia, which suggested his system to him. The system is very similar to that found in certain synesthetes in Group A, both in the nature of its appearance and in the direction of the lines representing individual instruments. It is obvious that his intellectualization of the system makes its present "immediateness" rather doubtful. It may be noted, however, that with sudden striking passages he does report actually seeing color. (Note that Valier reported this same phenomenon.)

Case study: Weber

Weber appears to be strongly synesthetic, but has developed little pattern or system. He shows no entoptic phenomena. Good visual imagery—auditory not so good. He felt that he could not draw any of the effects he obtained.

1. "Kind of film of misty dark lifting up. Moves—not stationary. Moves slowly like a lifting fog."

2. "Red not steady—flashes—no pattern or direction of flashes." (Recalls tune and gets same flashes but not as vividly as before.)

3. Nothing.

4. Associates it with Christmas but does not see wreath or anything but red. Complete field. Mixture of red and green—no sharp contrast—diffused throughout the whole field.

5 "Kind of bluish haze—stationary—not much movement."

6. Sudden red flash. "Cannot imagine it again—cannot visualize how it was."

7. "Bluish green haze again."

8. Nothing.

9. "Dull gray misty colors."

10. "Orange, red—all brilliant colors. No pattern or anything. All intermingled with each other."

Low noise. "Gray, dark, dull."

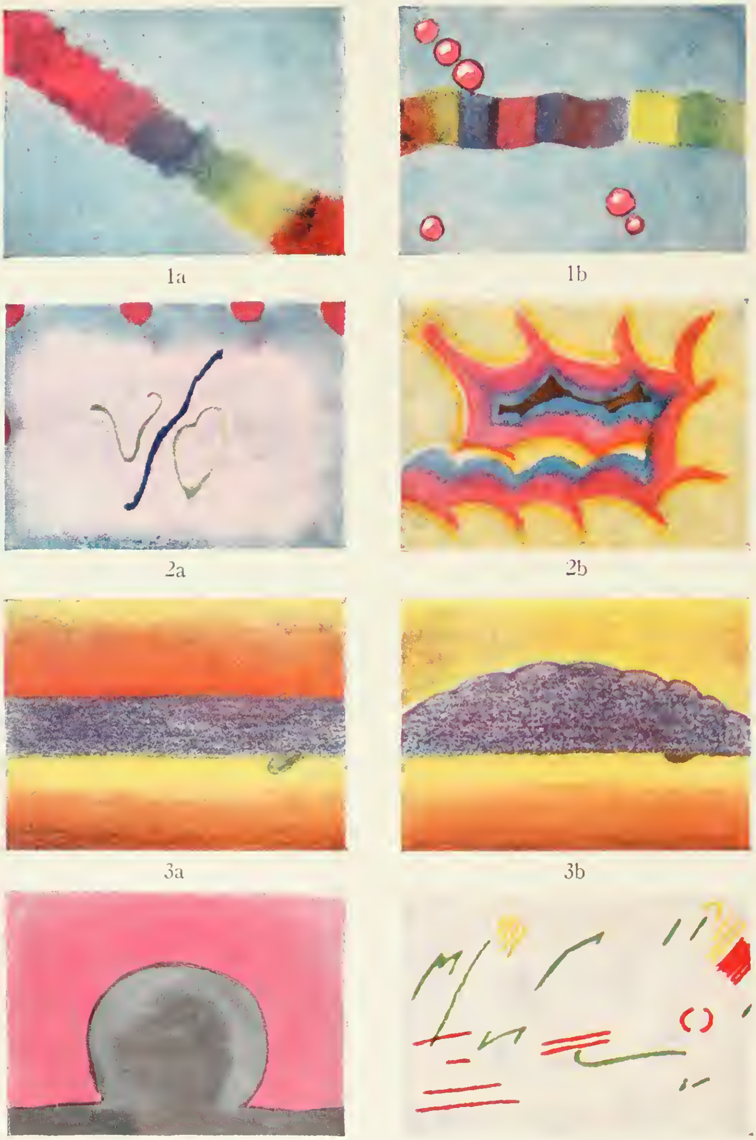
High noise. "Quite irritating—just brilliance—kind of blinds me."

2. (Repeated.) "Red—yellow and orange—mixture of them—no blues or dark colors."

4. (Repeated.) Red and green field.

Subject has synesthetic pattern but does not realize it. Experimenter tried to tell him his system. He said he knows that he gets bright colors with fast music and dark dull colors with low notes. Colors are not dependent upon affective tone—he likes some fast colors and also some slow tones. Tuning forks: 256 ~, grayish; 512 ~ light gray; others nothing. Has played piano for five years. Likes to play piano once a week or so. Mother and father very musical. Likes to hear jazz on radio. Likes hymns. Gets color from organ tones. Organ is soothing. ("Do colors aid in enjoyment?") "That's why I enjoy organ. It is no definite color. As if in a room with same hue—kind of restful." Does not enjoy too bright material. High notes too are shrill—irritating in both sound and color. "When I like a high fast trumpet tone I enjoy it." Does not remember childhood experiences. Seems always to have had this experience. "Never struck me as unnatural or peculiar."

At this point it may well be asked how many of the cases here classified into three groups conform to the traditional views of synesthesia. Warren's Dictionary defines "synopsia" as "a type of *synesthesia* in which visual sensations are closely associated with auditory sensations and appear regularly whenever the latter are stimulated. (Usually a given quality of visual sensation is associated with some specific quality of audition.)" This definition implies two things: firstly, correlation of sensory aspects of the auditory stimulus with visual contents, and secondly, the consistency of this correlation with repetition of the stimulus. The second point is treated in the following section on consistency of response. Concerning the first point the results from the rudimentary and complex groups show that such correlation, more or less, actually is present. The difference between rudimentary and complex cases is partly a matter of vividness of the photisms or sensations but even more a matter of the number of components of the auditory pattern represented in the visual surrogate, or in other words of the accuracy with which the auditory sensory pattern is translated into visual terms. The terms clearness and acuity are better than vividness.



1a

1b

2a

2b

3a

3b

4

5

PLATE I
(See opposite page for key.)

Strangely enough the first criterion is in some measure also satisfied by the synesthetic imagery group. Tables 2 and 3 indicate that in general the colors reported by the imagery group for each of the five short selections are quite similar to those reported by the rudimentary group. It would seem then that on a photistic continuum the members of this group more or less coincide with those of the rudimentary group. We have given them a middle position in our classification because the pictures they draw are so complex that more correlation with the auditory stimulus may be present than is apparent, due to the difficulty of isolating the musically colored element embedded in the meaningful picture.

Meaningful representation introduces difficulties in comparing sensory patterns. One way to handle this problem is to consider colored hearing as taking place at different levels such as the sensory level and the meaningful imagery level. It is conceivable that correlation between visual mental content and auditory content may take place at both levels. Furthermore subjects like Osgood suggest that the correlation may take place on an imageless thought level, and there is some indication that for some subjects the correlation may be one essentially between auditory content and feeling.

IV. Consistency of Response

The problem of consistency has many aspects. We may ask how regularly subjects obtain any response at all, how constantly they show a specific response to a specific selection, or how closely they conform to some individual system of response when the

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KEY TO PLATE I

1a. First drawing by Hartung for full phrase of "Squareface."
1b. Second " " " " " " " "
2a. First " " Scotford " " " " "
2b. Second " " " " " " " "
3a. First " " Sayre " " " " "
3b. Second " " " " " " " "

4. Drawing by Jones for Tschaikowsky's "Dance of the Flutes." This is a sample of a rudimentary response showing full design form.

5. Section of first drawing by Bentley for full phrase of "Squareface." This is a sample of the "sound track" form.

(Note that Panels 1a, 2a, 3a, and 5 show the responses of four individuals to a first hearing of the same phrase. A comparison of Panel 1a with 1b, 2a with 2b, and 3a with 3b, indicates the degree of consistency shown by three of the four individuals in their drawings for the same phrase upon hearing it again after an interval of approximately eight months.)

responses are not strictly constant. A related problem concerns how responses to parts of phrases compare with responses to the complete phrases. A wider problem, which we have as yet scarcely touched upon, concerns the congruence of a subject's form of colored music with other aspects of his personality.

In considering how regularly subjects obtain *some* response, we note that individual subjects were picked from the original questionnaires partly by frequency of response. It will be recalled that a positive response to all five items on the questionnaire was shown by 4% of the subjects in Group B and by no subject in Group A. Of the twenty-four subjects studied individually from Group B, three reported either photism or imagery for every selection and tuning fork. One subject always had some visual experience except when one tuning fork was sounded a second time. All of the others reported that they lacked experience with at least one selection, one subject reporting nothing for four of the ten selections. (The selections which most frequently evoked no response were the single measures.) Less than half reported color for all tuning forks. In general, the frequency of response to music ran very high with our individual subjects, but for none of the subjects can we say with certainty that visual experience is inevitable when music is heard with the eyes closed. Concerning the subjects not studied individually no very exact statement can be made. However, a comparison of their questionnaire results with those of the subjects individually studied makes it seem very likely that many of these subjects had definite visual experiences, but with slighter degrees of regularity.

Material from two or three sources pertains to the *constancy of response* to a given selection. From all it seems sufficient to state findings in terms of tendencies rather than of precise percentages, particularly since absolute constancy is a rare and practically undemonstrable phenomenon.[8]

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[8] Subjects would occasionally volunteer that their photism or image for a certain selection was "just the same" as it had been in the class investigation. Very few did this for more than one selection, and on the other hand some subjects reported that their responses were definitely different. Any descriptions on the questionnaires were too fragmentary to justify their systematic comparison with the later individual reports.

In most of the individual sessions at least one selection was played twice. Some subjects, indeed, asked that a selection be repeated if their photism was not clear at first, and in such cases they seemed to obtain an elaboration of their first experience. Repetitions later in the hour tended to give results closely similar to though seldom identical with the original response. In the case studies already presented it will be noted that Weber saw a red and green field for both presentations of Selection 4. His first report on Selection 2 was, " Red not steady—flashes—no pattern or direction of flashes." His second report was, " Red—yellow and orange—mixture of them—no blues or dark colors." North with two repetitions of Selection 6 reported variations in clarity, but found the general experience the same. There were some changes from one single color to another, for instance from gray to green. By and large the changes were not striking in character, the greatest changes tending to be with subjects reporting meaningful imagery.

Consistency of response after an eight-month interval. In a single session memory, uniformity of mood, and a desire for consistency may combine to favor similar responses to repeated selections. The retesting of eight subjects from Group A after a period of about eight months indicates what sort of consistency appears when at least the first of these factors is less important. Subjects heard the same selections repeated, and again drew any photisms which they experienced. Experimental conditions were as similar as possible. Subjects had not seen their earlier drawings in the interim.

Evaluation of the results is peculiarly difficult because judgments are in terms of similarity and not of identity, and because each subject's consistency must be estimated in relation to his total range of photisms. Some subjects have a relatively narrow range of photisms for all selections as compared to the total group, and others show a considerable variety of response. It is less remarkable for a subject who experiences a band of moving color with every selection in the first session to have similar experiences in the second than it is for another subject who experiences a band of color for only one specific selection in the first session to have a similar experience in the second.

A complete answer to the question of repeat consistency in colored music would thus require an elaborate study with a carefully determined range of selections and a technique for indicating degrees of similarity of photisms. Several of the problems of colored music might profitably be approached through the matching technique.[9] In the absence of such a study, however, the writers feel that the case studies and illustrations presented later in this section point clearly to the sorts of results which might be anticipated.

For most subjects some observable degree of relationship appears between drawings of a given selection in two sessions. At times this similarity is clearly apparent in color and pattern. At other times the same pattern may be repeated in slightly different colors, or similar colors may appear in different sequences (here the tendency is for the pattern to be more fully developed at one time than at another). At still other times two drawings which seem not greatly similar when viewed in isolation show some affinity when they are compared with drawings for other sorts of music by the same subject. The relationship may be a matter of brightness or " mood " which shows similarity even though neither color nor pattern is repeated. Occasionally the only consistency seems to be in broad types. Thus O'Connor is generally vague and irregular in his photisms, but he does tend to have one sort of photism for single measures and another sort for continuous passages. Some subjects may have photisms uniformly less developed at one session than at another (see LeComte and Smillie) and still show some traces of uniformity in the photisms which they do obtain. For every subject some pairs of drawings are definitely less closely related than others. And the number of pairs is not inconsiderable for which the writers would have difficulty in pointing out any certain relationship (except that they were both the creations of the same subject). In brief, the results show an appreciable degree of consistency which demands explanation, and at the same time a marked variability which suggests that the explanation must be complex. The music in its physical aspects seems by no means to be the only factor involved.

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[9] The matching technique is discussed in detail by Vernon (**18**). For our present problem judges might observe a number of drawings by the same subject—let us say five drawings from the first session in one row and five drawings from the second session for the same five selections in another row—and attempt to say which drawing in the second row should be paired with each of the drawings in the first row. Comparison with chance success of matching would indicate the degree of consistency of that subject (within the limits of competency of the judges, and within the range of musical selections employed). Judges could take into account color, pattern, and the total quality and mood of the photisms in a way not possible with more analytic techniques. Another sort of matching experiment might involve pairs of drawings by a number of subjects, all for the same selection. A third experiment of considerable significance would involve matching a series of drawings with the musical selections which called them forth.

The variability in itself has interesting implications as to the nature of the psychological processes in colored hearing. It must be kept in mind that there is considerable variability in the perception of music by non-synesthetes. At one time the melody may be attended to, at another time the accompaniment. Such fluctuations might be expected to influence the photisms of synesthetes, if the linking of color and music occurs on a complex perceptual level.

The variability of response also suggests that subjects do not require a sense of absolute pitch for colored hearing, as has sometimes been suggested. The important thing in colored hearing is not the particular color for the particular sound but the relation of colors to each other. Two different patterns of colors seem to be appropriate to a musical phrase if the relations of hues to each other are similar, even though the actual colors may be different. If a certain hue is established for the first notes, the following hues are determined accordingly. The arousal of the first hues, which act as points of reference, depends on complicated internal factors.

The response to isolated measures as compared to the response to a complete phrase. The case studies which appear below present material bearing not only on repeat consistency but also on the problem of how a response to a total phrase compares with the response to the measures of that phrase taken in isolation. Whether this second problem is a question of consistency or not would appear to depend upon what theory of sensory functioning is held. If colored hearing is regarded as dependent upon a specific relation of visual and auditory frequencies or brain areas an exact relationship would seem to be demanded. If, on the other hand, colored hearing is seen as a function of a total *pattern* a complex relationship might be expected which would involve consistency only at a more advanced level.

As previous case studies have indicated, the situation actually found was indeed a complex one. Perhaps in no phase of the study was a lack of any one-to-one relationship of sensory elements more evident. The closest approach to an exact relationship was in the case of Lake, who saw blue beads on a blue line for a whole phrase from "Squareface" and one or two blue beads on a segment of line for certain single measures. Yet even with Lake three of the seven single measures introduced some second color which did not appear in the drawing for the complete phrase. These other colors seemed to represent transition notes which had a different value in isolation than in their natural positions. At the other extreme from Lake is Sayre, who consistently had photisms for the separate measures but experienced strikingly different photisms for complete phrases. In general the photisms for single measures were less fully developed than those for complete phrases. If the measure was vague and indefinite the photisms might remain very primitive; if the measure happened to have a definite quality of its own the photism tended to do likewise. Measure patterns did not appear to be fragments of phrase patterns although sometimes they might have a similar color scheme. A much more complete study of this problem should be interesting from the point of view of Gestalt theory.

The following abbreviated case studies will hint at the degree of repeat consistency and at the relationship of measure responses to phrase responses.

Bentley is a complex synesthete who perceives colors in lines, but only with somewhat extended phrases. With single measures he reported that he felt "as though the color were just about to appear," but that was all.

For the first playing of "Squareface" he drew a sequence of light, disjointed lines, developing along a band from left to right. Figure 1 indicates the pattern of these lines. In Figure 1a most of the horizontal lines are maroon, the single horizontal lines somewhat above these in the second part of the piece are green, and the two very top lines are yellow. The jagged lines are green; there are two stray red lines and a blotch, and two yellow blotches. A portion of this drawing is reproduced in Panel 5 of Plate 1. The second playing, pictured in Figure 1b, is also largely in greens and yellows, with maroon and red both present but less prominent. There is a tendency for the colors to be in closer relationship, almost superimposed. The subject reports that these colors rise out of the background, which is "all colors and yet apparently no color." He is unusual in that he notes the music down as it is being played, asking for two or three repetitions to get in all the detail. Each of the six drawings he made for six selections has its own character in color and line, with a slight leaning toward maroons, reds, blues, and browns, which he feels may be due to the fact that none of the selections was especially pleasant.

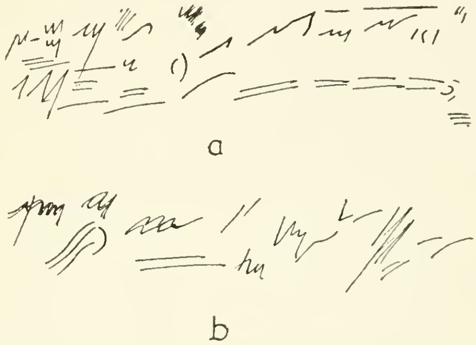

FIGURE 1

Hartung is a complex synesthete who tends to perceive a moving band of color developing from left to right against a vague background which he says is determined by the first notes. This band effect was more persistent in the second session than in the first, so that an attempt to match his performances would encounter certain difficulties. The first measure of "Squareface" in both cases started as a blue band, which in the first session turned to green and developed toward the top of the field as well as to the right, but which in the second session turned to a darker blue and continued straight to the right. In the first session measures 2 and 3 produced an even field of red, 4 a field of blue, and 5, nothing. In the second session 2 produced a lavender band with three swellings, against a vaguely blue background; 3 produced a blue band which at the end turned upward and tapered off, showing a rapid sequence of lavender, blue, green, and yellow; 4 gave a wide purple band tapering markedly at the end to a short red band; 5 was a purple band with drops of yellow coming in to it from above. Measure 6 in both cases showed a uniform change from preceding measures. In the first session it was an even gray field; in the second a gray band so wide as to cover almost the entire field. Measure 7 in the first session was a green band with two swellings rising from lower left to upper right, in the second session it was a red band with an early swelling, against a blue background.

The full phrase of "Squareface" in the first session gave a band of colors developing from the upper left of the field toward the lower right corner. The drawing is reproduced as Panel 1a of Plate I. In this band one color followed another in close succession, each color occupying the whole width of the band. The background was a light blue-gray. The second playing gave a band (pictured in Panel 1b of Plate I) similar to that in the first, but moving horizontally across the field from left to right, against a very light blue background. A number of red circles in the drawing represent "balloon-like things starting from the side and going toward the center, getting larger and finally evaporating." In other drawings the subject shows a certain rough consistency in complexity and coloring, along with a variation that was rather considerable in view of the fact that his entire repertoire of responses was limited in range.

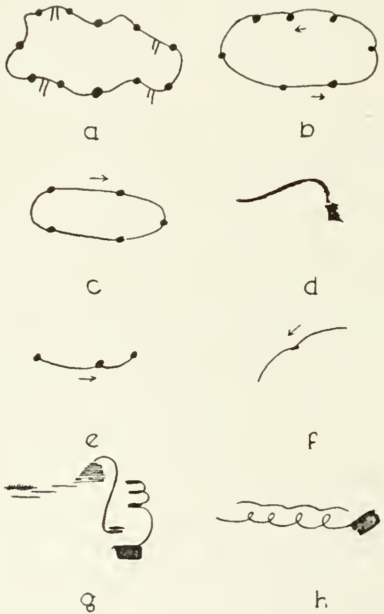

FIGURE 2

In the case of "Solitude" the earlier parts of the two drawings are quite dissimilar, but in each drawing four abrupt notes at the end appear as blotches of color.

Lake produced drawings of relative simplicity and clarity, some of which are here reproduced. Figure 2a is his drawing for the first playing of the complete phrase of "Squareface"; Figure 2b his drawing for the second playing. Both of these were drawn entirely in blue. In the first session he had no photism for any of the single measures except measure 5, which appears as Figure 2c. Figure 2d represents the same measure in the second session, the main part of the line being in blue and the last segment in maroon. Figures 2e and 2f show the drawings for the first and second measures in the second session. They are reproduced because they come as close to suggesting elements of a larger pattern as do any drawings in the study. Figures 2g and 2h show the first and second drawings for "Solitude." Figure 2g is all in blue except for the cone-shaped figure and the background of the first line, which are yellow. The lower line in Figure 2h is blue. ending in a brown "flag"; the upper line is of reddish lavender. These two drawings obviously show less similarity than those for "Squareface." Another selection in both sessions gave a wavy broad line with the upper part one color and the bottom part another, but the colors were maroon and black in the first session, blue and brown in the second.

LeComte appears to be a rudimentary synesthete. He repeatedly expressed doubt about his photisms and insisted that most of his effects are very vague, usually too vague to draw. Yet the sort of report which he gave, and the frequency with which he could point to a location and a development of his photisms makes it seem likely that they are not, as he fears, "just suggestion."

In both sessions there seemed to be a tendency for colors to appear around the fringes of the field, and only occasionally in the center. In the second session he suggested that it was as if he were wearing opaque goggles and saw color only above and below them. One photism which he reported twice in the second session looked as if from two uprights at either side of the field "a current or something was pulling something toward the center with piercing notes, which then retreated with less piercing notes." This was the only photism which he drew, and something very similar appeared in the first session, for another measure of "Squareface." His first report on "Solitude" was: "This had a much greater variety of colors all in the center of the screen I see. But they were colors of a creamy shade. Often ivory with creamy yellows, pale blues, reds, and green all on the center of the screen, sometimes together, sometimes alone." His second report was: "A very little shimmer from the left eye. One circle, no color, and not solid, moving from upper left toward right corner. Faded before it got there. I didn't notice it till near the middle. . . . Thought I saw the old bar coming again. It seemed to be bent, coming from both sides."

He showed a general consistency in type of report, though he felt the effects were less vivid in the second session. The vagueness of the photisms makes any very systematic comparison difficult.

O'Connor, like LeComte, is a rudimentary synesthete with irregular appearance of photisms. He drew only eight photisms out of thirteen selections in the first session, and four in the second. For single measures these tended to be vague masses of color. Thus the second measure of "Squareface" first gave a green field, while at the second session it gave something which he could not draw in exact color, but which seemed like three long narrow clouds one above the other with lighter color between. The fifth measure at first gave red at the left of the field in something of a step formation; in the second session it produced a band of yellow, tapering off to the right. The seventh measure in both cases was red and suggested loops, but the precise pattern was different. Longer selections gave bands of color, if anything. "Solitude" at first gave a snake-like band developing largely from left to right, but with two turns toward the lower left. The first part of the line was blue, the last part lavender. The second session produced a green band, broader and shorter and straighter than the first, with edges showing a number of slight waves.

Sayre is one of the most advanced synesthetes studied. Each selection resulted in a rather well-developed photism, and the photisms were quite consistent from session to session. The first four measures of "Squareface" produced oval or tear-shaped figures against a brownish-purple background, and each of the other measures showed characteristic changes. In all measures there was some slight variation. Thus the first measure first evoked a tear-shaped figure moving from lower left to upper right, with a center of dark purple and a border of yellow, while it later produced an oval figure one-third the size of the tear-shaped figure, but of the same color and direction. The fifth measure on both occasions introduced yellow arcs at the left of the field, with a suggestion of blue. The sixth measure showed one yellow arc at the left of the field, but whereas the first drawing has one blue rectangle at the right of the field, the second has two blue and four red rectangles, arranged somewhat like radii of the arc. The seventh measure on both occasions showed an abrupt change of quality. A gray pin-wheel effect turned slowly in counterclockwise direction against a background of broad horizontal stripes of alternating light and dark gray. In the second drawing the wheel appears a bit larger and the stripes a bit less definite, and the wheel itself is fringed with yellow. As compared to any of the other drawings these two are very obviously related. The total phrase of "Squareface" resulted not in any combination of these clearcut consistent photisms but in a much more colorful photism unlike any of the others he experienced. First and second drawings for the phrase appear as Panels 3a and 3b in Plate I. Again it will be noticed that a marked relatedness appears along with a certain change in detail. Some of this change may be merely a matter of drawing. The subject pointed out later, for instance, that the rather pronounced extension downward of the dark purple in the earlier drawing has its parallel in a very slight dipping of the dark part of the later drawing. In other photisms the subject tended toward a rather peculiar angle pattern, sometimes in color but usually a light gray against dark gray. It appeared in various positions and sizes. In the second session the subject said he associated it with something, but he wasn't sure what, and he did not remember having had the same effect before. Inspection of his earlier record, however, showed that he did have very similar angles for two pieces.

Scotford is another complex synesthete. His photisms appear as colors which fill more and more of the field as the music progresses. Patterns are sometimes vague, sometimes rather complex. At times he obtains a double-line effect, blue and green for instance progressing from left to right across the field, one always just above the other, and both rising and falling with the melody.

He saw nothing for four of the shorter measures in the first session and one in the second. The third measure of "Squareface" aroused a vague spreading of purple from the bottom of the field at the first session. At the second session the color again came from the bottom of the field but was more complex, a first band of blue being followed by narrow bands of purple and yellow and a wider band of blue. The photisms for the fourth measure developed from the lower right corner on both occasions and both contained purple and red, but the second drawing is more patterned and shows in addition a darker purple, a brown, and a yellow. The photisms for the sixth measure were on the left of the field in both sessions and both included purples and brown, but the patterns were quite different. The first drawing shows an extra shade of purple while the second shows yellow, red, and brown. The seventh measure on both occasions had a background of blue or bluish purple with bands of yellow and green, but in the first session the band went from lower left to upper center, while in the second it went from upper left to lower center, and included two strips of blue as well. The drawings for the whole phrase of "Squareface," reproduced as Panels 2a and 2b of Plate I, are perhaps the most divergent of this group. "Solitude" on both sessions produced a band effect, but at the first session the band was a yellowish-green and went from lower left to upper center, while in the second session it was of two shades of blue and stayed in the lower part of the field.

Smillie. This subject appears to be a complex synesthete who doesn't enjoy the experience. He drew his photisms in the second session hurriedly and said it is no fun. He said: "The music hits you, you feel it, then you see color—if you want to." Questioned about this qualification he said that it was about like hearing music in the next room: "You unconsciously hear it all the time—if you want to listen you can." He feels that at times the music gives him an idea, and the rest is imagination. In comparing two photisms which appeared pretty dissimilar he said of a blue background in the earlier one, "I guess that's how I represented infinity then."

The complexity of the photisms and the fact that they were drawn with more time and care in the first session makes their comparison a bit difficult A few sample drawings must suffice. The first drawing for the first measure of "Squareface" shows a wide band of green crossing the field, at first dropping slightly, then expanding greatly to fill most of the field at the right. The background is pale green, with flecks of yellow In the second drawing of the first measure a band of green, much narrower, rises slightly across the field. An irregular blotch of red appeared at the end. The first drawing for the second measure is of an indefinite field of colors, roughly horizontal in development. The lower part is in shades of blue, with a bit of green and maroon; the upper part is pale yellow, with a strip of red along the top. In the second drawing for the second measure a wavy line of blue extends across the field and rises somewhat. At the center a yellow line starts somewhat above the blue and crosses it at the right of the field. The total phrase first gave a complex pattern, predominantly gray, green, lavender, yellow, and black, with lines of red and blue and green at the top of the field. Some of the colors were vague in outline while others, like a zigzag line of green, were very sharp. The second drawing is much less developed. The lower part of the field is green, while above this a line of red crossed the field and above that some blue. The upper left corner is black.

In most of this subject's drawings some consistency of color appears, and sometimes a rough similarity of pattern. For one short measure the similarity of pattern and color arrangement is very striking. For another measure the sudden appearance of large amounts of black is interesting. (It may be noted that this is measure 6 of "Squareface," for which Hartung also suddenly reported black.) By and large, however, there is an appreciable difference in pattern, only part of which can be attributed to the difference in care with which the photisms were drawn. (It appears quite compatible with our other observations, however, that a hurried feeling at the second session might well alter the actual nature of the photisms.)

V. Discussion—The Nature of Colored Hearing

By way of summary we may indicate the range of facts with which a theory of colored hearing must deal.

1. There appears to be no single one-to-one relationship between color and music which holds for all subjects, nor which holds with demonstrable precision for more than a small number of individual subjects. Colored hearing is a field where the problem is very seldom one of identity or difference, but rather one of degree of similarity.

2. The response seems almost always to be a pattern response to the total stimulus, rather than a summation of responses to parts. Transition notes out of context give a change in color which does not appear in photisms for a complete phrase. One subject shows one type of photism for single measures, another type for the total phrase. Another subject reports that while a crash in the music usually causes a spread of the photism, if the photism is already extended the crash makes it contract. Still another subject claims that low-tone and high-tone colors are relative within the octave. A similar tendency has been reported in a previous study (15). In many of these cases some "frame of reference" seems to be established within which the relationships hold.

3. Several factors other than the music itself contribute significantly to the final response, at least with some subjects. The variability of our questionnaire results points in this direction, as well as many findings in the individual sessions. Distractions may interfere with a response. The familiarity of a selection may determine the color of a photism or the nature of an association image. It is possible that for a few subjects even the fact that a selection is being heard for the second time alters the response. The frequency of a left-right development of photisms seems related to reading habits. It is probable that this is only one of many such cultural influences.

4. In spite of the variability of response, certain general relationships of photisms to special aspects of music do constantly recur, in the general literature and in our own results. For instance:

a. Increase in brightness tends to accompany rise in pitch.

b. Increase in brightness tends to accompany quickening of tempo. (For some subjects the degree of illumination in which colors are seen increases with quickening tempo.)

c. Pattern of the photism frequently is related to "pattern" of the music—graceful lines accompany smooth music, jagged lines accompany staccato music or syncopation.

d. Position and direction in the visual field vary with pitch for some subjects.

e. The background color for some subjects varies with the first notes or with the key of the selection.

f. Photisms sometimes move in a third dimension—apparently approaching the subject with music of striking quality.

g. Photisms sometimes expand over greater area with an increase in the volume of the music.

h. Movement around a center mass may accompany turns or trills.

i. Lines of different color may represent instruments of different timbre. (As suggested above, these lines may rise and fall with changes in pitch.)

j. Colors may fit the " mood " of the music, or its pleasantness.

5. There are certain basic patterns of response. This fact has been obvious throughout the discussion. We have classified subjects as showing rudimentary synesthesia, synesthetic imagery, or complex synesthesia. A more extensive sort of classification would indicate certain general patterns of response, two or more of which may be found in a single subject. For instance:

a. Cloud, film, or veil effects, which may billow vaguely.

b. Spreading sheets of color, which overlay one another.

c. Points or limited areas of color, which may move or expand or contract with changes in the music.

d. Developing bands or ribbons of color which we have designated as the simple band, the multiple band, and the sound track.

e. Colors which gradually fill the field in complex patterns.

f. Meaningful images, which may show some dominant color or degree of illumination.

6. The rôle of association in colored hearing is a complex one. There are on the one hand the relationships indicated just above, such as that between pitch and brightness. Some writers regard these as matters of analogy or suggestion through language; others regard them as based on some degree of unity of the senses. There is much evidence for the latter view although this important issue demands much further work from a variety of approaches.

But even beyond these basic and commonly experienced associations there are the individual associations with past experiences or meaningful images. Almost all writers regard such associations as contributing nothing to synesthesia or interfering with it. But we have pointed to many cases in which any line between meaningful imagery and synesthetic photism would be drawn only with difficulty. Certain colorful forms of imagery such as elemental scenes from nature are readily aroused by music. And at times subjects seem to attribute meaning to photisms which first appear only as simple patterns of color. Some subjects respond always with abstract photisms, others respond always with concrete, meaningful, and not particularly colorful imagery. If a subject has both strong visual imagery and tendencies to associate color with music the compromise may lie in the arousal of meaningful imagery in which color is the dominant aspect.

All of these observations suggest that the final explanation of colored hearing may involve not one theory, but many. It seems certain that several factors contribute to the experience, and probable that these factors contribute in very different degrees to the experience of different individuals. For some individuals strong entoptic phenomena seem to determine the direction of colored hearing. For other subjects strong visual imagery determines another direction which colored hearing may take. For still other subjects cultural influences may be quite important in the response. Suggestion may operate through language and attitude in a variety of ways. It should be stressed that although one of these factors may be dominant in some individuals and another in others, surely none of them appears to operate in any pure and simple fashion.

Theoretical implications. This summary of the observed facts is typical of the literature in this subject. The pronounced differences in the color effects between individuals and the inconsistencies within the individual have made theorizing on synesthesia rather precarious. Many of the speculations have been based on study of a single case. Seldom have large numbers of synesthetes been studied beyond the level of statistical treatment of questionnaire responses. In some respects the data here assembled are unique. The methodology of breaking the musical composition into its component measures may have elicited information which could not have been obtained otherwise. In general we are confident that the method of analysis on the complex level of the musical measure has much to recommend it because color hearing is not as spontaneous and immediate as is generally assumed. It is built up, or as one subject put it, "the colors warm up. At first they are weak but gradually become more intense and colorful." This is probably the reason why we obtained a relative poverty of responses with simple pure tones.

We suspect that there is more uniformity in the results than the apparently diverse figures indicate. It is true that identity is seldom present but it is equally true that similarities are continually suggesting themselves. Reference has been made to certain "frames of reference," so to speak, within which the synesthetic pattern is developed. The several kinds of "frames of reference" that have been particularly clear cut we have summarized as forms of response, such as the single band form, multiple band form, and sound track.

With this rich and varied material at hand, it is appropriate to reconsider the data for uniformities traceable through them. Here we must be somewhat more interpretative because although the data are quite sufficient for interpretation there are gaps that have to be bridged by leads based on the continuities actually uncovered. The following analysis then purports to show the nature of the psychological processes underlying colored hearing.

Two chief gradients recur in terms of which practically all the drawings may be related. The first and most primitive is the figure-ground gradient; the second is the gradient formed within the figure or the ground (or sometimes within both). The ground seems usually related to the non-melodic notes representing the basic harmonies. These notes are characteristically not represented individually, their total effect rather being denoted by a homogeneous color. If the ground aspect of the music is rich and voluminous the ground color is heavy and saturated, but in proportion as it lacks character it is represented as blackness, or it is merely omitted. The background is relatively stable and stationary. In some cases it remains constant throughout the selection; in others it changes with the more striking changes of harmony or pitch level. In certain cases, moreover, there is a definite gradation in the background at a given moment. In such backgrounds the tendency is to use broad, banded colors.

The figural aspect of the music is apt to be the dynamic part. In its simplest form it is merely a region of greater brightness, or a different color of rather indeterminate shape. Generally it is more differentiated in terms of shape or motion. The sounds of distinctive instruments are brought out in more or less detail. At times one instrument carrying the melody may determine the figure. At other times several dominant instruments in their various harmonies may be represented as seen motion of the figural colors, which consequently form strange shapes and patterns. The figural aspect tends to be shown in smaller bands and lines if the music is reacted to in parts, or in shapes of various size if the melody is reacted to as a whole. The more common tendency in the complex cases is to separate the elements of the figure into component lines and scrolls.

An examination of the various sorts of response will reveal how these gradients appear. The rudimentary synesthetes show the most primitive arrangements. Usually the musical background is represented in a mass of color which more or less fills up the visual field. The very simplest rudimentary types merely have a mass of vague coloring with no distinctive figure-ground aspect. The richer color in this case may itself be regarded as the figure as against the dark background of the visual field as ordinarily seen in the dark. These subjects represent musical compositions in much the same way as if they were hearing only the pure sounds of tuning forks. Apparently their color reaction to music is simply a response to the general pitch level or harmony of the composition. More often figural aspects are recognizable in the development of a brightness difference in the homogeneous field, or of vague geometric forms. In the more advanced instances of the rudimentary group the figure-ground relation is clearly indicated with more or less structuring of the figural aspects of the music. Indeed, the responses of the rudimentary synesthetes foreshadow all the structures shown by the highly developed cases. These instances may be enumerated as follows: 1, a mass of color to denote the musical ground; 2, patches of brighter color denoting the figure; 3, shape of the figural color to indicate melodic action (spirals, circles, bands, etc.); 4, spatial localization of the brighter colors and shapes to indicate the pitch level of the figural aspect of the music. (The higher the pitch level the nearer the top of the synesthetic field.)

Another tendency appears in the rudimentary subjects which becomes increasingly important with the complex synesthetes, and which must be examined in detail. This is the tendency to perceive color in bands with a definitely directed notion. It has already been pointed out that motion is very frequently present in photisms. At times this motion involves merely the expansion, contraction, or revolution of vague masses of color, or the development of shapes within a fairly fixed frame. Very often, however, the motion has a definite direction, which results in the very common band photisms.[10] These deserve considerable analysis.

The *simple band form* is shown by both rudimentary and complex synesthetes. The band may represent either the figural or the ground aspect of the music. If the subject chooses to represent the lower base aspects of the music in the band colors, figural aspects may still show up as dots, circles, scrolls, etc., above, below, and across the bands.

In this case the pitch level of the music may be represented by the spatial position of the band in the visual field, high position for high level and low position for low level. Usually the band represents the figural aspect of the composition, the ground aspect being indicated by a vague background color. Brightly accented notes of individual pieces may be indicated by circles and other forms as in Panel 1b of Plate I. According to our interpretation in Panels 1a and 1b the band represents the figural aspect of the music, because a background color is indicated. The simple band forms are usually drawn from left to right. They may have sharply delineated edges in which case they suggest flowing rivers, or they may have frayed edges.

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[10] One possible reason for the frequency of these bands is that they enable the subject to develop photisms for new phases of the music, while still perceiving something of the earlier photisms. Such an arrangement would be especially useful for subjects whose photisms tend to persist.

The multiple band form, as represented by Scotford, is somewhat more complex. Scotford tends to accent the figural aspects of the composition, representing the timbre of the different groups of instruments by thin parallel bands. The base level is indicated by a vague background color. Panel 2b of Plate I is a complex example of his photisms. Unlike most subjects, he runs his bands in various directions, reverses motion and finally fills a circumscribed area to form a design of parallel bands. When the area is filled, more music tends to overlay new bands on the old ones and thus to obliterate them. The synesthetic pattern is in continual change and movement.[11] While the band as a whole tends to rise and fall with the melody, the lines for the separate instruments remain in their same relative position. The blend of colors may represent the characteristic blend of instruments for that particular selection. When the figural aspects of the music are not dominant affectively, the figure is not analyzed into parallel lines but rather is represented by its total empathic value in terms of shape.

The *sound track form* has been so designated in our protocols because it suggests the ordinary sound track or oscillograph representation, or sometimes a number of them superimposed. The analogy is particularly apt because all the three advanced cases of this type reveal striking resemblances to the sound track. In the first place they all tend to see a moving band, each segment of the band representing a detailed analysis of the music at that particular moment. The colors are thus seen in short spans in a definite place. The band moves from left to right as if a color ribbon were moved through an aperture. The immediately previously seen parts of the band are also present in a somewhat less clear state. All three subjects used the band formation to represent the figural aspects of the music. The base tones are represented by a background color which is more or less homogeneous. On this background thin lines of various colors and shapes take form. The lines usually depict the various instruments and the changes in pitch of the individual instruments are indicated by changes in the size, shape and thickness of the lines. Usually the lines are broader at the bottom and thin out and change their shape with rises in the pitch. Bentley requires many renditions of the same musical compositions because he claims he cannot get all the details in one presentation. His final products tend to be complete transcriptions of the figural aspects of the music in the form of thin variously-shaped lines. Osgood has a similar system. Unlike Bentley, who likes music because of the colors he experiences, Osgood is hardly conscious of the colors. With him it seems to be a system of music notation in terms of which he remembers music. Temperamental differences are probably responsible; one sees things from the point of view of science, the other from the point of view of art.[12]

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[11] It should be noted that Panel 2a, which represents Scotford's first response to the same musical selection, is not a multiple band, but a full design form. When Scotford was asked why the same music caused such different representations, he said that music is very complex and that his pictures are determined by the aspects which he isolates. Ordinarily he prefers the figural parts of the music and Panel 2b is typical of his work. Apparently the base tones indicated in the purplish and bluish background of Panel 2a were dominant when he first heard the composition.

The *full design form* is best represented by Sayre. Sherwood and Smillie have similar forms.[13] Sayre usually sees the color in the shape of a square which, projected at a distance of a yard, is about six inches to the side. Unlike most of the subjects discussed under simple, multiple and sound track form his photisms rise from the bottom and swell out upward till they completely fill his square color field. The shift of movement from conventional left to right direction, the fact that he tends to fill the whole square in solid color, and the pronounced presence of geometrically designed patterns embedded in the color make his color patterns distinctly different from the band forms just

[12] The third subject with sound track photisms has not been previously discussed because he was a member of Group A who graduated before he could be retested. His photisms were remarkably similar to those of Bentley and Osgood though a bit more primitive. Panel 5 in Plate I is an illustration of Bentley's color-hearing. It is part of a phrase from "Squareface." See page 32 and Figure 1a.

[13] Sherwood is the other subject from Group A who was not retested.

discussed. Sayre's forms are typical of the reproductions of synopsia in Anschütz (1). The rudiments of his form are obvious, moreover, in examples from the rudimentary groups such as Panel 4 of Plate I. This figure is taken from Jones listening to " The Dance of the Flutes." In Jones' photism there is a relatively homogeneous color field in which a circular pattern becomes differentiated. With Sayre the whole process is more complicated. The field is often more highly differentiated, sometimes into broad bands of horizontal colors, with all sorts of figures embedded in the color. Circular, crescent, and oval shapes frequently recur in his drawings.

Sayre is an interesting case because he tends to correlate color with the basic harmonies, and forms or shapes with the figural melodies. Because he has such pronounced empathic responses to both color and shape, the following interpretation of his own color hearing is offered. This analysis was written in the presence of the experimenters one and a half years after he was first interviewed.

> " Since this experiment began, I have attempted to find some general rules which would govern the type of photo-synthesis (*sic*) experienced by me. My success in finding general rules has been limited. I have found that the visual experience is composed of color and figures.
>
> " Color seems to be the direct result of the 'warmth' of the music. By warmth I mean overtones, harmonies and backgrounds generally pleasing to the ear. Warmth is found in *almost any well-played* instrument. However, the greatest color comes from rich and soothing harmonies, generally of a deep pitch. The human voice offers color, but less as the voice develops a quaver or is high pitched—these latter two diverting the impression from color to figure. High-pitched instruments such as violins, must be well played to give color, while lower-pitched instruments can give color without being played by masters. The rhythm seems to make a difference in the color too. A sharp rhythm, a fast rhythm, or short notes change the color to figures, while a slow rhythm giving longer, sustained notes adds to the color. The color is *not* due to the musical background entirely, since I do not listen to the outstanding or solo instrument always and make the background really my dominant center of attention, from which I derive my figure and color.
>
> "*Form. Color* appears more slowly than figure. It does not move greatly, but rather increases saturation to the visibility point. It disappears immediately at the cessation of the tone. If the tone changes too rapidly, the colors do not have a chance to become bright, but give way to a dominance of figures. *Figures* are always moving either in direction, size, position, or intensity. Their appearance is instantaneous upon the beginning of the tone. They give way to color when the tone has 'warmth' but dominate color if, though the same warm tone, the tone is broken by sharp rhythm, short notes, etc.

"*Figure* seems to be due to anything startling. This includes high pitches, shrillness, sharp rhythms, short notes, beats that are very prominent. They are active on the visual field as mentioned above. Their action is different in every case where there is a difference in any of the factors mentioned above. Three peculiar figures I find recurring. First is an oval, circular, or tear-drop shaped body made up of concentric colors. Motion may be in any direction or circular, is generally slower than for most figures. This figure occurs most commonly, since it is found in a medium-pitch, medium-length, even tone, such as those produced by a trombone. A second figure is one of angles, due to higher tones, shorter notes, etc. The motion here is faster, less persistent in memory due to more rapid change. A third figure is composed of dots and sharply angular lightning-like streaks, and results from shrill, chopped notes. As tones become slower, fuller, deeper than the figure first mentioned, the color rather than the figure becomes dominant.

"It is interesting to note that figures generally completely dominate the background when the notes are shrill and sharp enough. I am not sure whether there is a red-brown dark background, or whether this color could be due to a small amount of light through the eyelids. This background is completely dominated by the figure when single notes or pure tones are reproduced. As the tone gets 'warmer,' the figure intensity, speed of motion, etc., all weaken, giving way to both color in and around the figure. As the tones become still warmer and slower, the figure gives way to waves of color which build from bottom and top, increasing in intensity as the tone continues.

"I enjoy the color far more than the figures. Hence, I appreciate the 'warmth' of Wagner and Beethoven more than the Italians for the most part, and appreciate the sound of a good trombone, cello, etc., more than a coloratura soprano. I do, however, enjoy some works which have short notes, high pitch, etc., such as Wagner's 'Ride of the Valkyries' and a good coloratura like Ponselle because they have some vivid, if flashing, color due to the overtones or harmonies that are there."

The "full design" type of drawing characteristic of Sayre's synesthesia requires a shift of emphasis in our analysis of colored hearing forms. Whereas the simple band, multiple band, and sound track forms seem to be various schemes for representing sensory factors fairly directly in visual terms, Sayre's full design form shifts the emphasis from sensory content to empathic effect. Figure-ground aspects are pronounced, although with Sayre the ground itself is more important than with many subjects, and has its own empathic quality. His photisms seem to arise in the manner of entoptic colors. They fill a certain circumscribed projection area to form a background of blended colors which represent the harmonic background of the selection (which he frequently prefers to the melody). These colors are often indicators of feeling tone rather than pitch. The richer, brighter, and more voluminous colors correlate with the more pleasing sounds. The colors grow out of each other and continually change in hue, volume, and intensity. They are relatively motionless. To some extent they form bands but the banding is not as pronounced as in the other forms, and the bands are not narrow but rather broad and diffuse which is what one might expect for representation of diffuse feeling tone. In fact, only a few of Sayre's drawings are banded. Sayre represents the figural melodies by empathic shapes such as tear drops, angles, and revolving masses. Very frequently these shapes are dark in color, indicating that they are unpleasant. Thus color and shape combine their empathic effects.

While Sayre tends to empathize rather than analyze, it should be stressed that none of the cases we have studied is exclusively analytic or exclusively empathic. A tendency toward analysis is seen in the contours of Sayre's patterns, which are often sharp or ragged, straight or rounded, depending on the pattern of the melodic notes. On the other hand both Osgood and Bentley, whose typical patterns are almost notational systems, report that they also experience empathic qualities. Bentley once wrote a verse based on a musical selection which produced colored lines suggesting gracefulness and pictures of swans. Osgood claims that certain tones which he depicts as lines have weight and that the music is experienced in gradations of weights, represented in the thickness and depth of lines. In general, individual tendencies to analyze or empathize seem determined by the individual's interests, capacities, and temperament. At the same time all schemata are subject to the common limitations of the human perceptual span, so that if the figural aspects are represented in detail then the ground aspects are relatively vague, and *vice versa.*

Such, then, are the uniformities of synesthesia as indicated by our data. The most primitive manifestation is a vague mass of color which more or less fills up the space used for color representation of music. At first this space is indeterminate, fading off at the edges just as ordinary entoptic colors do. This mass becomes differentiated at a higher level into two or more colors more or less blended together. At a still higher level these colors become better differentiated and consequently are represented in the drawings as bands. Figure and ground relations are next brought out. Usually the banded region is the figure and the vague coloring around color bands serves as the ground part of the music. At a later stage the figural components are embedded in the bands which serve as ground.

This study indicates further that color, particularly of the ground part of the music, carries feelings of empathy such as ordinarily indicated by the words deep, smooth, full, calm, soft, gentle, etc. The figural aspects connote their empathic quality in the shape of the figures and lines suggesting in their contour the shape of the melody.[14]

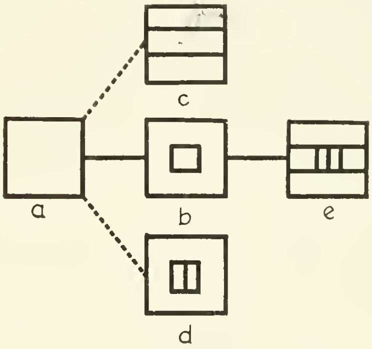

FIGURE 3

Figure 3 indicates the nature of the uniformities between the various kinds of pattern tendencies in color hearing. In the figure, A represents a homogeneous color response to a musical selection. This simple form of pattern has been found in cases suggesting an entoptic basis for synesthesia. Usually these entoptic colors show a vague differentiation of figure and ground. This fact is represented in B, where the small square stands for figure and the large square for ground. In C the ground is graded or differentiated in colors. The ground gradient is indicated by horizontal lines. In D the figure is graded and this is indicated by vertical lines. In E both figure and ground are graded. The E type is found only in the most complex synesthetes.

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[14] Practically all our drawings, except some of the very primitive types, show figure and ground accents. The figure and ground relationship confirms what we know about figure and ground in ordinary visual perception. The figure is perceptually clearer and more distinct. This study, however, indicates emotional preferences are not exclusively determined by the figural aspect. This is a matter of temperament. Some subjects prefer the softer background tones, and tend to inhibit the sharper figural tones. Weber for instance answered our question as to whether or not he enjoyed colors accompanying music by saying that he enjoyed them particularly in organ recitals because the music is full, soft, and melodious. In more typical music the sharp jarring instrumentation is apt to elicit unpleasant color experiences. Other subjects have expressed similar opinions. It would seem then, that emotional or *affective configuration* and *perceptual configuration* may be independently variable.

The phenomena of meaningful imagery and empathic response in the form of shapes do not add anything new to the diagram. Either figure or ground may be experienced in terms of meaningful symbols, or of geometrical shapes, although shapes usually appear as figure. Meaningful pictures and geometrical shapes represent higher level syntheses of the component factors in the music. This diagram should not be regarded too literally, but rather as an abstract representation of pattern variations.

The analysis of the entire range of color hearing patterns into bands or something similar to them seems to be true in proportion that the hearer himself is analytic in his color representations. However, the hearer does not always present an analytic picture. Sometimes the color pattern is quite synthetic, sometimes one aspect of it is analyzed, the rest synthesized. The melodic aspect of the music is apt to be analyzed into component parts especially if the figure is preferred and attended to more than the ground. If the condition is reversed and the ground is the more interesting to the hearer, then the figural parts are blended together into a synthetic product, which is represented as a shape symbolic of the general contours of the figural melodies. This tendency is found in the rudimentary group as well as in the complex. Very frequently the subjects in the rudimentary group respond with a homogeneous color in some definite shape. It would seem that such rudimentary cases were responding particularly to the figural parts of the music with a synthetic drawing. There are other rudimentary types who simply indicate a homogeneous color field without any definite shape. Such cases we would regard as the limiting case for the band type.

VI. Discussion—The Art of Color-Music

It was suggested in the introduction that color-music as an art form has greater possibilities than has commonly been granted by psychologists. In fact, several of our findings which are puzzling to the psychologist should be encouraging to the artist. The number of cases having definite photisms and the larger number indicating some association of color with music show that the relationship is not rare or generally unacceptable. The more commonly reported relationships are comprehensible to most people even when they are not directly "sensible." The questionnaire results are of interest in this connection. While it may be argued that the strongly positive results in Group B were partly due to suggestion the fact remains that suggestion unplanned, and in fact guarded against, must have found very ready subjects to be so effective. The suggestion back of an established art form should be much more potent.

A frequent objection to color-music as an art form is that no one system of relationships could satisfy all the individual peculiarities of synesthetes. This objection may hold for a limited number of advanced synesthetes who have rigid and clearly defined systems, and especially for subjects who tend to see photisms even with their eyes open. We encountered only one subject who obtains photisms at all regularly with his eyes open, and few subjects with very rigid systems. The fluidity of colored hearing is one of its striking characteristics. If photisms alter from time to time through random influences they might readily alter to conform to a generally accepted system. The common characteristics which synesthetes display offer a good starting ground for such a system.

It is true that some subjects are fluid only within their particular sort of pattern. Instruments may always appear as lines in a moving band, even though the movements and colors of the lines may vary. It would be interesting to expose such subjects to colored patterns of other kinds, to determine whether their own effects might change. Even if their own effects remained constant they might still enjoy color productions of other sorts, merely feeling a preference for one sort of color composition over another, just as a person may prefer symphonic

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or polyphonic music.[15] One of the basic factors of esthetic pleasure is the variety of patterns available.

One fairly fundamental division of color-music may be foreshadowed by our synesthetic imagery group. This is a division between the more meaningful and the more abstract forms of color-music. Since our synesthetic imagery subjects use many of the devices of other synesthetes, many of them should be able to appreciate and enjoy abstract and empathic color patterns. On the other hand, they might continue to prefer a larger element of literal representation in their color-music. In the history of art the tendency for some artists to be literal and others abstract is always present. We may contrast Hogarth and Rembrandt in the past, while today the surrealists are the story tellers (albeit the stories are of thoughts and not of things) in contrast to the abstractionists.[16] These two trends may well continue in color-music. Meaningful color-music may really be the more fully developed today, in the form of the colored animated cartoons in which music, action, and color produce a unified effect.

A color-music can be imagined, then, broad enough in range to satisfy the patterns of practically all synesthetes. It is more important to ask if such an art form would be acceptable to the world at large. While the number of people experiencing photisms with music is larger than is generally believed, this number might still constitute a rather limited audience for an art form which hoped to invade the cinema and eventually the television screen. Can the psychologist predict how people might respond to color-music who are not synesthetic in the traditional sense?

Many facts indicate that the audience for color-music might be nearly as universal as that for any art form, because the phenomena usually considered as synesthetic seem only a special development of a very fundamental tendency in perception. The tendency to translate experiences of one sense into another sense is widespread, and of all the possible references the visual is by far the most common. This translation can take place on many levels. In some of the early cases of synesthesia a linkage was found so definite as to suggest an interlacing of nerve fibers. But the usual variability of response points strongly to other factors. With many people emotion stands as a middle term, the music arousing a mood and the mood being represented in visual terms. In some cases the translation may come through the sort of analogies which are common in the language. (It may be left as an open question, which the development of color-music may help to illuminate, to what extent these relationships are inherent in the sensory experience and to what extent the language factor is a necessary middle step.) In still other cases a fully developed meaning is the transition, a story or "program" suggested by the music and then visualized, or if it is verbalized, verbalized in a language weighted with visual references.

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[15] It is interesting in this connection to note that Paul Lamparter (7) found that tendencies to perceive form or color more readily were related to tendencies to prefer certain forms of music over others (such as marches over waltzes).

[16] Pickell's finding (12) that the synesthetic imagery subjects were more extraverted than the complex subjects suggests a psychological basis for these two currents in the story of art.

The widespread and varied manifestations of this linkage seem to imply a primitive unconscious visual frame of reference which is aroused ordinarily by visual objects. The sensed analogies between sound and sight set off this already established visual frame of reference, which was built up in the individual and possibly in the race to serve the purposes of perception. Sound is ordinarily inadequate to set off these unconscious visual references, but with some subjects the suggestion of similarity between sound and sight is enough to arouse visually established responses. In this sense synesthesia is a reflex response to an ordinarily inadequate stimulus. The influence of such a perceptual field of reference is seen in many instances in ordinary vision, notably in visual illusions, since it is becoming increasingly apparent that visual illusions are difficult to explain in simple peripheral terms such as eye-movement. They seem to be the result of expectancies established by the unconscious frame of reference within which perceptions operate. The fact that color hearing is the most common form of synesthesia suggests that the perceptual frame of reference is quite well established in most people because vision is the dominant sense modality.

The potential audience for color-music is thus by no means limited to the proportion of people having clear photisms on hearing music. It includes all who find comprehensible the translation of auditory experience into visual terms. In the last analysis, active visualization need be no more a requirement for the appreciation of color-music than auditory imagery is for the enjoyment of music.[17]

It may be asked why an art with such a wide potential audience has never been more fully developed, and particularly why it has never developed a folk form. The probable answer is that a full development had to await the invention of adequate mechanical devices for presenting colors with sound. The pleasure which people have long taken in watching brightly-costumed folk-dancing (apart from the social aspects of such pleasure) may reflect an early desire for this sort of experience. The modern development of the dance, with its emphasis on patterns of color and movement (and also on the empathic implications of exaggerated postures) certainly represents in part an extension of this interest. Only recently, however, have devices been available for a widespread development of color-music. And at the present time, since Vitaphone has flooded the theater with sound and Technicolor has made practicable the complex patterning of color, we have indeed something suggesting the folk art of a modern age in the widespread popularity of Silly Symphonies and similar cartoons which combine color and music with a universal humor. It is interesting that these films receive a ready welcome even while their creators are still uncertainly groping for adequate esthetic effects. It is perhaps inevitable that the more rarefied forms of color-music should be preceded by these early experiments built around an earthy humor, just as the more refined forms of the dance today spring from the primitive pleasure in dancing as a form of physical and social expression.

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[17] One interesting effect of the development of color-music might be an increase in the number of people experiencing photisms with music. The difference in the frequency of positive reports in our two groups makes the sound-sight relationship appear very sensitive to suggestion. Howells (5) has recently reported success in establishing a quite arbitrary association between a specific tone and a specific color in the laboratory, so that subjects were eventually unable to tell whether an illuminated field was or was not colored. If such artificially established linkages are possible, the writers feel that the constant repetition of relationships based on commonly accepted analogies and reënforced by the prestige of an accepted art form would considerably augment the number of color-hearers. They also predict that the conventions which would inevitably be established in color-music would have the effect of narrowing somewhat the range of individual patterns of response.

A question remains concerning the place color-music can expect to take among the already-established arts. Various attempts at color organs have been viewed with interest, but as yet have had no very wide acceptance. In at least one American symphony hall which was quite elaborately equipped with apparatus to vary the lighting with the music, the effects had to be discontinued because of the objections of some of the subscribers. Is this resistance due to any inherent limitations to color-music?

Some of the objections to color-music are undoubtedly of a temporary nature. The builders of early color-organs must inevitably be overconcerned with methods of color-projection, and limited in their color patterns by available techniques. Indeed they face problems such as a symphonic composer might face if he had to devise a scale, design all the instruments in the orchestra, and plan the acoustics of the hall.[18] The crudeness of early color effects is probably especially striking when they are blended with familiar symphonic music, which represents a high development of a long and complex musical tradition. Furthermore, resistance is likely to be especially marked in cases where private associations have already been established with symphonic music. These facts suggest that color-musicians may anticipate greater success when they more fully work out certain basic principles, develop a surer technique, and compose both music and color patterns in a single unit.

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[18] Robert Edmond Jones points to this concentration on technical aspects as a difficulty in the development of the color film. In a very provocative recent article which appeared after the present monograph was written (New York *Times*, Feb. 27, 1938, Sec. 10, p. 4) he argues that the first colored films have been unsatisfying because producers have not realized that the colors on the screen differ from the colors in Nature (in psychological terminology, they have been trying to treat "film" colors as "surface" colors), and that moving colors on a screen involve esthetic problems never before encountered. Jones points out that moving color has the emotional quality of music, and anticipates the growth of a new art form when this fact is more widely recognized. While much of his discussion might fit an art of color-music, it might equally well pertain to a moving-color art form, either meaningful or abstract, unrelated to music. Such an art form has interesting possibilities, and it might achieve the same sort of unity in the visual field that much music achieves in the auditory field. Certainly many problems of color patterning will have to be worked out independently of the relation of color to sound. (It is possible that many of our subjects experienced no special enjoyment from their synesthesia just because there are unpleasant aspects to many color patterns induced by music which has been composed with no thought of color relationships.) The writers venture to suggest, however, that the linkage of sight and sound is close enough so that when the problems of moving color patterns are satisfactorily worked out, a demand will arise for a musical accompaniment just as surely as the demand arose for a piano background in the early days of the movie.

More permanent objections to color-music may be hinted at in the somewhat limited audience for the dance and for opera, where visual and auditory patterns have been planned to form a unit. But here color-music would seem to have certain advantages over the older forms. Ballet and opera have always had difficulty in maintaining a consistent degree of remoteness from reality. Incongruities caused by casting and production troubles have become stock subjects for burlesque. Even with the most auspicious of productions there is likely to be for many a feeling of incongruity between the sight of the characters, the sounds they utter, and the meanings they convey. Wagner, speaking the voice of gods, continually tried to develop stage techniques to help his characters overcome the usual stage limitations, but he often succeeded only in reminding audiences that these were but mortals on a stage. The cinema has been conspicuously more successful in conquering limitations of time and space and gravity, as with its magic carpets, yet even here, wonder at the mechanics of the process is likely to interfere with esthetic enjoyment. The clash between the reality of the characters and the unreality of the situations remains.

On the other hand, the best of the animated cartoons have shown that quite consistent effects can be achieved when sounds, figures, and situations are all somewhat equally remote from reality. A fully developed art form should achieve much more striking effects. Some of its patterns will undoubtedly involve traditional characters in traditional situations, perhaps with their imperfections refined away. The fact that pictorial art has tended in the past to be much more representational than music may cause some disturbance in blending the two media. It seems probable, however, that continued familiarity with effects achieved by drawing farther away from visual reality will make the appeal of abstract color patterns more widespread.[19]

VII. SUMMARY

A preliminary survey of 274 college students revealed 165, or 60%, who showed some tendency to associate color with short musical selections. Because of variations between the results from two groups these figures must be accepted only with reservations. Individual study of thirty-seven cases selected on the basis of these first results revealed thirty-four with definite photisms or strongly colored associational imagery.

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[19] Since color-music will go through a period of trial and error it is impossible to anticipate exactly the form it will finally take. Practical matters of projection and commercial development may be quite as important as any cues taken from the present uniformities of synesthetes. These uniformities, however, suggest certain leads which might profitably be followed.

Today theaters simply flood the stage with varying colors. The continuance of this practice no doubt indicates that it has found favor with the audience. Stage flooding satisfies the simplest conditions of synesthesia as shown by our least advanced rudimentary subjects. The photisms of most subjects make a greater concentration of visual effects in a somewhat limited area seem desirable. The cinema screen is perhaps the most adequate and practical medium for the development of such effects. (Conventions established here could be transferred to the television screen when color projection is adequately developed.)

The wide appeal of the cinema should make it possible to experiment with color-music at the various levels of colored hearing. We have already suggested that for the rudimentary group a simple flooding of the screen might be adequate, and that for the synesthetic imagery group representative pictures might be most satisfying. The complex synesthetic group represents the most fully developed abstract response to music, and the system developed for this group might simply be reduced or modified for other groups.

In general, the principle of figure and ground should be fundamental. The visual ground usually correlates with the prevailing harmonies, the figure with the melody. In the more representative depictions the landscape could be related to the musical ground, and living creatures or active objects to the melody. In the more abstract patterns, figure might be used to represent sensory aspects of the music or empathic responses to it. For sensory aspects, bands of color might be employed; for empathic responses, shapes of color. (While much is still to be learned of the correlations of shape with music, several studies (8, 13, 20) have already indicated uniformities in the empathic effects of lines.) In addition to the figure-ground relationship, conventions might readily be established for the vertical and horizontal dimensions. The horizontal dimension might be related to the development of the music in time; the vertical dimension to changes in pitch. A third dimension of depth may eventually be available to denote volume or intensity. Certain color conventions will also certainly be established, such as the use of bright colors for higher pitches, and "thick" colors for voluminous music. Finally, the fact that some of our subjects represent high pitch by spatial location and others by bright colors points to the regions of freedom which color-musicians will encounter in setting up their conventions.

Different patterns of response led to a classification of these subjects into three categories. Thirteen cases showed "rudimentary" colored hearing, with a predominance of simple colored photisms. Twelve cases showed "complex" synesthesia, with photisms of rather fully developed system and pattern. Nine cases showed "synesthetic imagery," with tendencies for strong visual imagery apparently combining with tendencies for colored hearing, so that unusually colorful images resulted, or photisms replaced images for some selections.

Some correlation is indicated between rudimentary colored hearing and entoptic color phenomena; between synesthetic imagery and ordinary meaningful visual imagery; and between complex synesthesia and eidetic imagery.

An analysis of the different patterns of response revealed considerable uniformity. The uniformities are described as typical forms of colored hearing. Four distinct forms were found. In the experimental protocols they were referred to by names which seem to suggest a picture of the form. Thus there are the "simple band," the "multiple band," the "sound track," and the "full design form." An attempt is made to trace structural similarities in these forms. The frequent occurrence of colored bands in all forms is regarded as significant.

The band structure of the color patterns is linked up with analytic tendencies in the color-hearer. Synthetic tendencies are shown in the form of shapes and geometrical figures which tend to reproduce symbolically the melodic shape of the music.

The color patterns in chromesthesia show figure and ground relations which correspond to the figure and ground aspects of the music. There is some evidence, however, that affectivity cuts across the perceptual figure and ground, setting up an affective figure and ground that is independent of the perceptual one.

Empathy for both color and form seems to be an intrinsic factor in the color hearing of some subjects.

Retests of eight subjects after a period of eight months indicated an appreciable consistency underlying considerable variation in response.

Photisms for single measures often varied widely from photisms for the total phrase from which they were taken. The pattern which the measures presented in isolation seemed to determine the response.

Meaningful colored imagery and synesthetic photism can be distinguished only with difficulty. Extraverts tend to respond to music with meaningful imagery modified by the colored photism. Introverts respond with abstract patterns in color.

The results are considered in terms of modes of analogy between sound and sight. The problem is one of perceived similarity. These similarities are partly cultural, partly linguistic, and possibly partly based on a primitive unconscious visual frame of reference which may be aroused by a wide range of stimuli.

The frequency and fluidity of the phenomena of colored hearing offer considerable encouragement for color-music as an art form. Such an art form should be acceptable to non-synesthetes in terms of their perceptual equipment, and after a period of development should have a permanent place along with other art forms.

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